INSECT PESTS

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"OLLETT" GOLD MEDALLIST, 1932;

SANITARY INSPECTOR, BOROUGH OF SOUTHGATE

With Twenty-Three Illustrations

LONDON

H. K. LEWIS & Co. Ltd.

1940

PRINTED IN GREAT BRITAIN BY THE WHITEFRIARS PRESS LTD.
LONDON AND TONBRIDGE

PREFACE

DURING recent years the study of insect pests has received an increasing degree of attention, an attention which is in every way justified when the effects produced by this type of nuisance is taken into consideration. Now, with the onset of hostilities and the altered, indeed revolutionized conditions associated therewith, the problem has assumed even greater magnitude. What was formerly and far too often considered little more than a nuisance, has now been finally recognized as a definite menace. The evacuation problem, the herding together of Military, Naval and Air Force personnel in emergency quarters, the mobilization of Civil Defence Units, even the necessary alterations in the sanitary staffs of local authorities—all these factors have played and are still playing an important part in bringing the insect pest into the foreground of our national conscience.

For this reason the authors hope that the present volume will prove of some definite and practical use to those authorities and individuals who have the responsibility of insect pest control placed in their charge.

An attempt has been made to cover the necessarily extensive field as adequately as possible, but in a volume such as this it will be evident that some aspects of the problem have had to receive less extensive treatment than others which appeared to possess more urgent and important claims. In a practical handbook such as this, summarised treatment is probably an advantage,

and it will also be appreciated that in no other way could the material at the authors' disposal have been compressed into adequate space. The authors trust that the essentials have been given requisite attention, and that no fundamental aspect of the problem has been omitted.

The authors wish to tender their most grateful thanks to L. Peverett, Esq., and his associates for numerous courtesies and expert assistance at various stages in the preparation of this volume; and to Dr. Fenton, Royal Borough of Kensington, and Dr. Dart, of the Metropolitan Borough of Hackney, for permission to reproduce various forms and office records. They are also indebted to Dr. Vynne Barland, Metropolitan Borough of Bethnal Green, for permission to reproduce propaganda leaflets. Acknowledgment is also made to H.M. Stationery Office for permission to include extracts from certain Acts of Parliament, Statutory Rules and Orders. They are prevented, through circumstances over which they have no control, from acknowledging their indebtedness to an eminent authority on insect pests, but they would nevertheless like it to be known that their gratitude is none the less sincere.

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CHAPTER I

GENERAL OUTLINES OF INSECT CONTROL

Introductory. The extermination of vermin is no longer governed by haphazard, rule-of-thumb regulations, but is a skilled procedure requiring the employment of scientific methods and of persons possessing considerable technical knowledge. It is only within recent years that the methods originally in use have been abandoned, following the pooling of ideas from different authorities. As might be imagined, this has resulted in benefit to the community. As part of the work of a Public Health Department, insect control and the disinfestation of premises and furniture is now receiving that attention which its importance has rendered long overdue. The degree of ill-health and suffering resulting from verminous conditions, particularly in the home, cannot readily be estimated, but it is quite sufficient to have caused the more enlightened authorities to make strenuous efforts to rid their districts of vermin of all kinds.

The invasion of property by a variety of insect pests has created a problem which is engaging the attention of public health, medical and commercial authorities throughout this country, as well as abroad. The bed-

bug, the flea and the louse are the more familiar enemies of mankind, and medical literature abounds in details of the toll of suffering and disease caused by these pests. To counteract the activities of such insects, a knowledge of their habits and mode of life is essential. For this, we have to thank the scientific entomologist, whose work in field and laboratory has considerably simplified the task of destruction. A lack of such knowledge on the part of operators leads to misdirected effort and to the wastage of valuable material.

While the knowledge of the habits of insects provided by the entomologist is of considerable importance, it would be of little value without the co-operation of the chemist, who provides the lethal weapons necessary for destruction. Chemists are constantly experimenting, with a view to producing new and more effective remedies. While many extravagant claims are made for a large proportion of these remedies, it is essential that they should be maintained in proper perspective until the validity of such claims can be fully substantiated.

Ironically enough, man himself has been largely responsible for producing conditions which enable insect pests to multiply and so become a definite nuisance. By the crowding of both the human and domestic animal population, and by the storage of all kinds of products which serve as their food, man has provided insect pests with an easily available and almost unlimited food supply, together with ample shelter in reasonably undisturbed conditions. Thus, the two essentials for rapid increase are to hand.

While there is an abundance, indeed a superabundance of suitable chemicals available for the destruction of

verminous insects, a dearth of skilled operators still exists, due probably to the lack of thought given to the work. The foundation of successful vermin destruction is an accurate knowledge of the habits, life history and environment of the insect in question, and it is only when this problem has been properly tackled and thoroughly understood, that the chemical and mechanical means of combating the pests can be utilised.

For these reasons, it is essential that persons in charge of disinfestation work should possess a sound knowledge of the following subjects:

(1) Elementary entomology.
(2) Materials used and the reasons therefor.
(3) The need for the application of certain materials in certain specified ways.

Until recently, and, indeed, even at the present time, the work of disinfestation was being carried out by inexperienced operators, using ineffective methods and supervised by individuals with the barest knowledge of the principles of disinfestation. This is particularly unfortunate, since the ability of the operator is of the very greatest importance. In addition to skilled workmen, satisfactory materials are also essential. Thus, the ultimate goal of pest extermination is the elimination of untrained men and the weeding out of poor materials, far too many of which are still in use. It cannot be too often emphasised that there are no short cuts to vermin extermination; neither are there any stereotyped methods of treatment, each case of infestation requiring attention on its own particular merits.

Methods of Control. Three fundamental principles

form the basis of all successful control, irrespective of the actual method or process. These are :—

(1) Correct time of application.
(2) Thoroughness in carrying out the work.
(3) Suitable means of applying materials.

The correct time of application is of greater importance than is often supposed, and should be carefully borne in mind when planning a course of treatment, as, in the life cycle of most insects, short periods occur when the insects are exceptionally vulnerable and are thus easily attacked and destroyed. Such periods can only be determined from a knowledge of the insects' life history. Thoroughness implies considerably more than merely using sufficient material and applying the correct process. Care is required in treating the most likely haunts in an efficient manner. Lack of such thoroughness is often the cause of failure, as suitable products, if applied in a haphazard way, will not yield satisfactory results.

It should also be realised that two separate aspects of the problem must be faced. These are :

(1) Prevention of the transference of vermin from infested property to new houses.
(2) Routine treatment of existing verminous property.

Experience has shown that infestation of new property can be avoided if the requisite steps are taken. Particular attention to this aspect of the problem is essential if infestation is to be avoided when persons leave old houses for new property. The ordinary routine treatment of infested houses does not call for any unusual methods.

The control of insect pests should be carried out in three progressive stages, as follows :—

(1) *Diagnosis of the Cause of Infestation.* Thorough knowledge of the insect and its habitat is necessary, particularly as regards the difference between harmless and noxious species.

(2) *The Remedy Required.* The methods to be employed in extermination and the chemicals required depend upon the insect in question and the prevailing conditions.

(3) *Application of the Remedy.* This is, in many cases, more important than diagnosis and prescription, since some insecticides, if properly applied, will exterminate all the household pests likely to be encountered.

From a control point of view, insects can be divided into two classes :—

(*a*) Those which bite. These feed by biting or chewing portions of their food. Examples of this type are cockroaches and crickets.

(*b*) Those which suck. These, such as bugs and fleas, puncture their food supply, sucking up juices through their proboscces.

Those insects which bite can be dealt with by means of poisoned baits, as can some of the sucking type. In the latter case, however, insecticides or fumigants are generally necessary and are definitely more effective. It should be remembered that all control methods are palliative, and that the cause of infestation must be traced and eradicated. Cleanliness, the removal of waste food and rubbish, sunlight, fresh air, sound construction

of buildings, together with soap and water will assist considerably in keeping persons and premises free from insect pests. In addition, delay in dealing with insects may lead to serious infestation, as the rate of increase under favourable conditions is prodigious.

Characteristics of Insects. Insects are included in the phylum *Arthropoda*. This group includes crabs, lobsters and centipedes in addition to insects proper, the group being the largest of the animal phyla. Insects are bilaterally symmetrical, the body being divided into rings or segments, of which a varying number bear jointed appendages. All *Arthropoda* possess a hard, horny exterior. This is less marked in some cases than in others, and is produced by the substance known as *chitin*. Chitin is insoluble in acids but not in alkalies. During growth, the external skeleton is moulted in its entirety.

Included in the phylum *Arthropoda* is the class *Hexapoda*. This class contains an enormous number of varieties of insects, which are to be found in all parts of the world. They are small animals possessing bodies made up of transverse segments, grouped in three distinct regions, as follows :—

(1) *Head*. Possessing six divisions.
(2) *Thorax*. Possessing three divisions.
(3) *Abdomen*. Consisting of a variable number of divisions, with a maximum of eleven.

Segmentation is distinctly seen in the abdomen and thorax. In the head, the segments have become fused, forming a highly chitinised box. The thorax bears the legs, which never number more than three pairs, and in addition the wings, when present. These latter

appendages may be present in one or two pairs. When present, they are borne on the second and third divisions of the thoracic region.

(1) THE HEAD. This is the first region of the body and, as previously indicated, is composed of a number of fused segments, usually regarded as six. These segments are intimately consolidated to form an extremely hard case. In the adult insect, the head usually possesses the following appendages:—

(*a*) One pair of compound eyes placed in what is the first head segment.
(*b*) One pair of antennæ on the second segment.
(*c*) The mouth parts.

The *eyes* require no particular explanation, being similar to the compound structures found in numerous lower animals. The *antennæ* are modified appendages of the second head segment. Each antenna possesses a number of segments, varying according to the particular type of insect. While the various functions of the antennæ are not well known, it has been fully established that they contain the organs of touch and smell, while it is also possible that some of the organs of taste may be found therein.

The *mouths* of insects may be comparatively simple or, as in the blood-sucking variety, exceptionally complicated. Generally speaking, the mouth parts may be grouped into three types:—

(i) The mandibulate type.
(ii) The piercing and sucking type.
(iii) The non-piercing and sucking type.

The mouth parts of the bed-bug and the flea are highly specialised.

(2) The Thorax. The thorax is the second region of the body and is attached to the head generally by means of an intersegmental area known as the *neck*, which is not fully chitinised. This second region consists of three segments, and contains the *wings* and *legs*. In addition, the thorax often possesses two, and in some instances three, pairs of *spiracles*, attached to the second and third segments, through which the insect gets all or some of its air. Other spiracles are present on the abdomen, though the number varies. In its simplest form the spiracle consists of an opening on the exterior of the insect for the purpose of admitting air. There is, however, considerable variation in the structure of the spiracles, and many possess a rather complicated apparatus for closure and for the exclusion of dust, dirt and moisture. In certain concentrations of carbon dioxide the insect is forced to open its spiracles. These spiracles are the openings to a series of tubes called tracheæ leading to all parts of the body. Each trachea branches and afterwards unites with other similar structures to form innumerable minute tubules extending to all the tissues and organs of the body. The tracheæ possess thin walls which have spiral thickenings, strengthened by chitin. These thickenings keep the tracheæ distended and allow free passage of air. The tracheæ terminate in minute tubes known as *tracheoles*. These are the essential organs of respiration. They lack a chitinous lining, but penetrate the tissue cells to furnish the necessary air.

(3) The Abdomen. The abdomen, which is the third region of the body, is composed of a series of segments, the first eight of which may possess pairs of spiracles. The last three or four segments are usually modified to

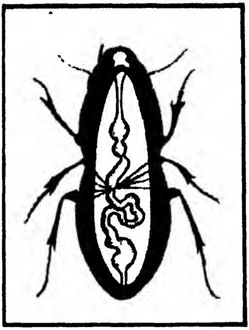


FIG. 1. The digestive system of an insect.

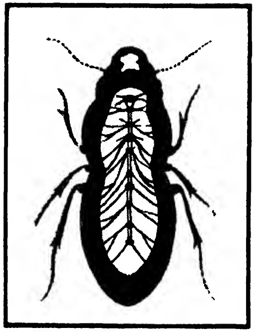


FIG. 3. The nervous system of an insect.

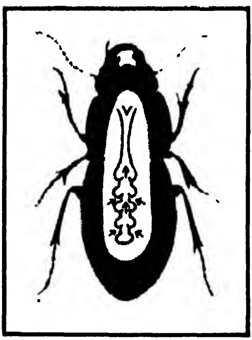


FIG. 2. The heart of an insect showing the circulation and direction of flow of the fluid contained in the body cavity.

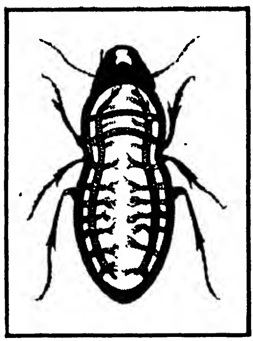


FIG. 4. The respiratory system of an insect showing how the tracheal tubes connect with the spiracles through which air is received.

By courtesy of Associated Fumigators Ltd.

form the *clasping organs* of the male and the *ovipositor* of the female. It should be noted that, while some insects possess eleven abdominal segments, it is often difficult to recognise eight or even less. The abdomen contains the digestive system and its appendages, the heart and the reproductive organs, and, as previously mentioned, a large proportion of the respiratory system. The digestive system includes the intestines, known respectively as the fore-intestine, the mid-intestine or stomach, and the hind intestine, together with the *salivary glands* and what are known as the *malpighian tubules*, the function of which are excretory. The *blood* is a fluid of varying colour which circulates and bathes all the internal organs and tissues, being kept in circulation by the cardiac action.

Metamorphosis of Insects. Metamorphosis is a change of form undergone by the majority of the denizens of the insect world. As an instance, from some insect eggs the young emerge, these later reaching the adult stage without any further change. In others the life cycle passes through a larvæ, and often, in addition, a pupæ stage before the insect reaches its adult form. The eggs of insects vary greatly in shape, size and markings. The eggs of the insects which cause annoyance to man all possess a distinct shell and are laid on or near the food upon which the young are to feed. The young larva makes its escape from the shell in three ways :

(1) By breaking the shell with its mandibles.

(2) By pushing off the cap or lid through forming an air cushion.

(3) By breaking the shell by means of special apparatus such as hatching spines.

The simplest type of insect does not undergo metamorphosis and its life history may be illustrated as follows :—

EGG—YOUNG—ADULT

One example of this type of life history is the silver-fish (*Lepisma saccharina*). In some cases it is difficult to differentiate between the last nymphal stage and the adult insect. As the hard skin has to be cast off or moulted occasionally, this moulting allows the various stages to be recognised.

Some insects undergo what is known as *incomplete metamorphosis* in the following stages :—

EGG—NYMPH—ADULT

The striking feature of this type is the development of wings, which become useful for flying only in the adult insect. In all other respects the young, which are called *nymphs*, resemble the adults except in size and the condition of the genital appendages. With this type of insect, the life of the young and the adult are exactly similar, as they live in the same situations and feed upon the same food. Bed-bugs, crickets and lice are examples of this type of development.

A further group undergo *complete metamorphosis*, as follows :—

EGG—LARVA—PUPA—ADULT

In this group are found flies, fleas, beetles, moths and butterflies. The young and adults are totally unlike in appearance. The egg hatches out to form the larva which, upon reaching maturity, ceases to feed and proceeds to undergo a remarkable change, either spinning a cocoon or forming a cell in the ground. The last

larval skin is cast off and the pupa appears. Within this pupa the larval tissues are changed and rebuilt to form the adult, which subsequently emerges. This type of metamorphosis exhibits the following characteristics :—

(1) The larval stage occupies a different habitat and requires other food from that of the adult stage.
(2) Wings develop internally during the larval period and make their appearance as wing pads in the pupal stage.
(3) A particular feature of this type of metamorphosis is the change from larva to adult in the pupal stage.

In many instances only the egg and the larval stage are vulnerable, although in still other instances the adult may also be attacked. In the pupal stage, great resistance is displayed, the pupæ being often inaccessible to control methods.

Growth of Insects. Insect growth is restricted to the nymphal or larval stages. Once the adult stage is reached there is no increase in size, although large quantities of food may be eaten. Growth is accomplished by moulting, *i.e.*, periodic shedding of the skin. As the skeleton of insects is external, it is impossible for any expansion to take place after the cuticle has hardened. In order to overcome this difficulty, the animals moult in the following manner. When the larva gets too large for its skin, the cuticle splits and a new larva emerges, provided with a soft external skin which is capable of considerable expansion. This new skin has been formed before the old is cast off.

Moulting takes place at regular or irregular intervals,

the number of moults varying with different groups of insects. During larval growth, large quantities of food are stored as fat. This is largely utilised during the pupal period, being employed in the development of the adult tissues. During the adult stage food is taken to provide for body activities, although some insects depend for their food supply upon the store of food remaining from the larval stage.

CHAPTER II

THE BED-BUG

Introductory. The bed-bug or *Cimex lectularius* is to be found throughout Europe and North America, Egypt, the Sudan and Australia, while its near relative, the tropical bed-bug or *Cimex hemipteras*, inhabits the warmer regions of the earth. In recent years, the bed-bug has assumed the position of a major sociological problem. This problem is not, however, a modern one, as the bed-bug was an unwelcome concomitant of civilisation in Ancient Rome. These pests belong to the order of insects known as the *Hemiptera*, and records show that they were recognised in this country at the beginning of the sixteenth century. Little is known of their place of origin, but it is thought that their home was formerly in the Eastern Mediterranean. As trade between the various countries increased, the bed-bug spread rapidly throughout the world. In this country, the bed-bug became established in seaport towns, and, even as late as the year 1730, is said never to have been seen inland.

The bed-bug is most often found in the overcrowded and badly housed areas of towns, but also infests better class property where strict attention to domestic cleanliness is not observed. Practically every local authority is faced with the bed-bug problem to a greater or lesser degree, but it is only during the last few years

that the position has assumed any real importance. That it has, is due to the education of those infested and the desire for a higher standard of sanitation.

Various estimates have been given as to the percentage of property infested. It is said that in some areas 90 per cent. of the houses are affected to a greater or lesser degree, although this figure is possibly excessive. Conclusions as to the extent of bug infestation are, however, best based on population and not upon the actual houses affected. This will be readily understood when it is stated that a very large percentage of bug infestation is found in overcrowded areas. Thus it is preferable to state that half the population of Greater London suffer from bugs to a greater or lesser degree at some time or other in the year. On the other hand, probably not more than 35 per cent. of the houses in Greater London are affected at any one time. This condition obviously calls for urgent action.

Appearance. The bed-bug is a flat, oval creature, some $\frac{1}{5}$ inch long and $\frac{1}{8}$ inch broad. It is a dull amber or chestnut brown in colour. The *head* is short and broad and possesses a pair of compound *eyes* which are black in colour. The eyes do not move, and each consists of a cluster of small, clear, round facets of various sizes. Two *antennæ*, each of which consists of four segments, are fixed to the under-surface of the head. The first two segments are stout and broad, the remaining two being longer and freely movable. All four segments are well supplied with fine, short hairs. When the bug is resting, the antennæ are directed outwards and forwards. Arising from the tip of the head is the *proboscis*, which is short and lies in a groove on the under-surface of the

head. This organ passes backwards from the front portion of the head to a position between the bases of the first pair of legs, and contains the instrument with

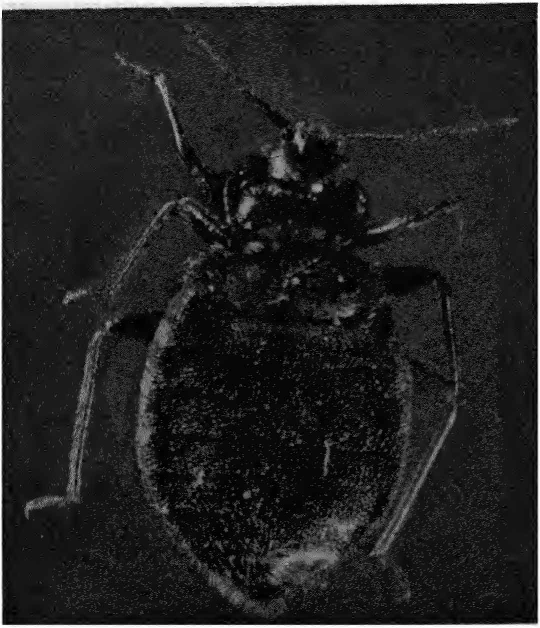
By courtesy of Messrs. Newton Chambers Ltd.

FIG. 5. Proboscis and mouth parts of bed-bug (*Cimex lectularius*) The labium is extended.

which the insect sucks the blood of its victim. The *head* is attached directly to the thorax without any intervening neck.

The *thorax* carries the *legs*, and is divided into three segments, as follows :—

(1) The *prothorax*, the largest segment.
(2) The *mesothorax*, much smaller.
(3) The *metathorax*, hidden from view by two small pads, which are rudimentary wing cases or *elytra*.



By courtesy of Messrs. Newton Chambers Ltd.

FIG. 6. Male bed-bug (*Cimex lectularius*).

Insects in the order *Hemiptera* are usually provided with *wings*, but in the bed-bug there are only two hard wing pads which represent the fore-wings, the rear wings being atrophied. To compensate for this loss of flight, nature has endowed the bug with six legs of the usual insect

type, by means of which it can move at considerable speed. Each leg terminates in a pair of *hooks*, which enable the insect to obtain a reasonably firm hold on

By courtesy of Messrs. Newton Chambers Ltd.

FIG. 7. Female bed-bug (*Cimex lectularius*).

rough surfaces. Each leg is coated with fine, serrated *hairs*. The secretions from the salivary glands prevent the clotting of blood during feeding, when the blood passes through the feeding tube into the intestines.

The *body* of the bug is entirely covered with fine,

short hairs, fringed with stout bristles. The *prothorax* is more or less semi-lunar in shape, its anterior angles being considerably extended. The *abdomen* consists of eight segments. The sexes may be distinguished by means of the abdomen. In the male, this is carried to a point, while in the female it is much blunter. In addition, the female bed-bug may be distinguished from the male by what is known as the *organ of Berlese*. This is a conspicuous incision in the posterior margin of the fifth segment, and marks the orifice leading to the female genital organs.

The tropical bed-bug closely resembles its relative of more temperate climates, except that the prothorax is narrower and less deeply excavated at the rear for the reception of the head.

When these insects have fed and are gorged with blood they present a curiously banded appearance, due to the exposure of the smooth, polished front portion of each abdominal segment. This, in the fasting insect, is overlapped by the posterior, bristle-covered portion of the segment immediately in front, the abdomen being contracted and presenting a dull, uniform surface.

Characteristics. Although the bed-bug is generally associated with slum property and want of proper cleanliness, the insect is often introduced into new, clean premises through the medium of furniture, books and clothing. Although these insects cannot fly, they can move with great rapidity and are capable of travelling in search of blood. They can and sometimes do migrate from one house to another. In warm countries they have been known to infest railway trains, while shipping throughout the world is generally affected. This is probably due to the fact that the bed-bug is

particularly able to adapt itself to the most varied conditions of environment.

The bed-bug is an insect of nocturnal habits, feeding on blood by night and hiding away in various parts of the room by day, although, in the case of heavy infestations in conjunction with a warm room, it may be observed moving about during the latter period. Because of the fact that its proboscis is constructed for feeding by puncturing and sucking, it is unable to obtain any nutriment from decaying wood or crumbling plaster. The usual habitats are :—

(1) In crevices and cracks in the plaster of walls and ceilings.
(2) Behind skirting-boards, architraves, picture-rails and other woodwork, including floorboards.
(3) Among books and papers and in boxes and trunks.
(4) Behind loose wall-paper.
(5) In picture-frames which have not been dismantled for some time.
(6) In spring mattresses and flock beds.
(7) In bed-frames, whether of iron or of wood, and particularly round the joints.
(8) In crevices round rusty nails and in nail holes.
(9) In places where woodwork has shrunk away from the plaster.
(10) In furniture of all types.

Bed-bugs are generally found in bedrooms, but on occasion they overflow into adjoining bathrooms and W.C.'s. In the case of heavy infestations they may be found in the living-rooms and even in the roof spaces. The surrounding walls and woodwork at the head of the bed often become infested first, and, in cases of mild infestations, this site may be the centre of the mischief. Should they become crowded out, the insects gradually

spread throughout the room, even invading the under-surfaces of linoleum, wireless sets, electric plugs, supply switches and gas brackets; while the under-surface of floorboards and roof spaces provide many suitable hiding places. Ventilators in bedrooms and bathrooms are frequently found to be infested, probably because of the prevalent practice of sealing this space in order to prevent draughts. Bed-bugs have alse been found in cavity walls, which provide a useful means of transit between adjoining houses.

During the night the insects emerge from their hiding places and attack the head, neck, arms or other exposed parts of persons sleeping in the infested rooms. It should also be remembered that the covered portions of the body are not immune from attack, while the bed-bug will feed on animals as well as on human beings. The bed-bug does not feed when gorged with blood. After feeding, when nearing its normal habitat, it invariably excretes. The fluid passed varies in colour. If the bug has been feeding on lymph, the colour of the excreta is yellow, while should the insect have fed on blood, the excrement will be black. The bed-bug never passes unaltered blood.

Bed-bugs, both young and adult, are capable of existing for lengthy periods without food and without diminution of energy. Experimentally they have been kept alive for many months without food in an unheated room during winter, survival for two years being reported. It should, however, be noted that enforced fasting prevents oviposition and retards further growth. Unfed, newly hatched bugs can survive a temperature of from 28° to 32° F. for considerable periods, while adult insects can live for four to five years with an

occasional feed, breeding being unimpaired. The length of time an insect can survive without food is decreased by raising the temperature. Conversely, it is increased by lowering the temperature.

It will thus be appreciated that the bed-bug is capable of adapting itself to severely restricted feeding, although starvation does modify the normal rate of growth. In this connection, it should be remembered that, even when infested houses have remained unoccupied for a considerable period, such premises cannot be considered free from bugs. Survivors will almost certainly emerge immediately the house is reoccupied. Bugs have been experimentally fed on the blood of rats, mice, rabbits and fowls, and, in cases of recorded longevity in empty houses, it is possible that the blood of these animals has been the source of the insects' food supply.

Bed-bugs emit a very offensive odour. This is due to two glands which open through separate orifices on the lateral surfaces of the metathorax. These glands are supposed to afford protection to the insects, by rendering their possessors distasteful. The glands differ in size in different bed-bugs, the extent of the odour emitted depending on the number of insects present. In some instances the odour is scarcely perceptible, but in other cases it is so strong that the presence of the bugs is made known before they have actually been detected. In each of the young stages of the bed-bug three such glands are present.

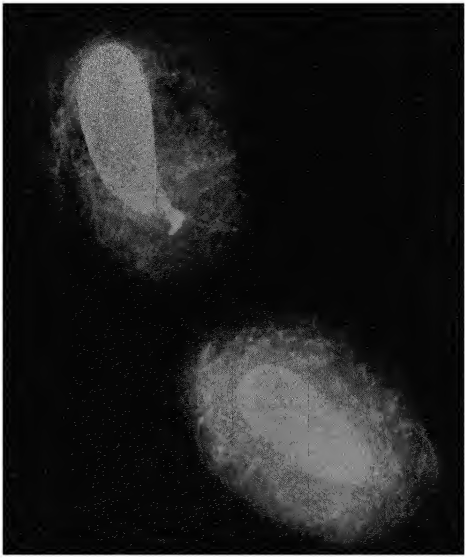
The insect feeds by puncturing the skin of its victim and sucking the blood. Heat is said to stimulate a desire to feed. The action of piercing the skin is not always successful, and several attempts may be made

before the bug settles down to feed. When a suitable spot has been found, the tip of the rostrum is pressed against the surface of the skin, and by a series of strong thrusts, the short tip of the tube, which lies in a segmented sheath, is made to penetrate the skin. The blood is sucked through the tube, into what is known as the "pump chamber," situated in the head. By muscular contraction, the roof of this chamber is drawn upwards and its capacity thereby increased. This causes the blood to flow up the tube and into the mouth. From there it passes to the pump chamber and on to the stomach. The adult insect is usually gorged in five to ten minutes. The sucking tube is then withdrawn and slips back immediately into the sheath of the rostrum. The bug then makes its escape. After a good meal, the bug shows no inclination to feed again for several days, in some instances for many weeks. This insect thus differs from the flea and the louse, which will feed twice or even more often within twenty-four hours.

A well-fed bug is more fertile than one which has fasted for some time, and a female fertilised by a well-fed male is said to be more prolific. The bed-bug appears to be more easily destroyed when well-fed than when starved.

These insects are more active in hot weather, but temperatures in excess of 113° F. are said to effect destruction. They are attracted by warm surfaces or by a combination of heat and smell, but this attraction only extends for short distances. The bed-bug finds its food by wandering at random. One interesting theory has been advanced to account for such perambulations. This states that bed-bugs are receptive to sound waves

and that either human voices or the noises made by persons moving about warn them of the presence of food.



By courtesy of Messrs. Newton Chambers Ltd.

FIG. 8. Eggs of bed-bug, showing the operculum from which larva emerges.

Life History. The life of the bed-bug may be divided into three stages, as follows :—

(1) Egg.
(2) Nymph.
(3) Adult.

(1) THE EGG. The eggs of the bed-bug, each of which is approximately $\frac{1}{20}$ inch long, are deposited in cracks

or crevices of woodwork and walls, in crevices of bedsteads, on mattresses, behind wall-paper, skirtings and architraves. They are pearly-white, elongated objects, tapered towards the upper extremity, which possesses a lid pushed aside by the young bug as it emerges from the egg. The eggs can readily be detected by the naked eye as minute, whitish granules. The egg is a little broader at one end than at the other, the width being approximately one-third of the length.

The eggs are laid during the breeding season, which extends from March to September, although this primarily depends on temperature. They are provided with a film of cementing substance, which immediately dries and glues them to the surface upon which they have been deposited. The eggs are laid either singly, in rows, or in heaps, and the female may lay from one to twelve eggs in twenty-four hours under favourable conditions. As many as 250 eggs may be deposited by the female during the breeding season. The laying of each batch of fertile eggs is almost invariably preceded by a meal.

If conditions are favourable, the eggs will hatch within ten days, when the egg cases lose their lustre and shrivel up. When the egg has hatched, the shell is white and iridescent and the lid has usually disappeared. The period of hatching may be considerably shortened if warmth is available.

(2) THE NYMPH. The term larva is applied to the insect during the first stage of growth until the first moult. This period varies from four to twelve days, but may extend to six months or more. When the egg is first extruded, the larva inside is fairly well developed, the eyes of the enclosed embryo being easily observed towards the narrow end of the egg, with

the assistance of a good hand lens, as a pair of pink spots. The young bed-bug makes its appearance as a minute, semi-transparent creature with red eyes. In other respects it is a minor edition of its parents, except that it is not so

By courtesy of Messrs. Newton Chambers Ltd.

FIG. 9. Second Inspar of bed-bug (*Cimex lectularius*).

flat, the antennæ are shorter, the wing pads are entirely absent, and it does not possess any sexual organs. Provided with a suitable opportunity, the young bed-bug will begin to feed immediately and will rapidly fill up with blood. The young insects, however, may not feed for some time after hatching; the young bug hatched

in autumn thus possesses sufficient reserves to enable life to be carried on throughout the winter without feeding. It is very important that none of the very young bugs should be overlooked, and equally important that they should not fail to be recognised during the spraying of insecticides.

At the termination of the larval stage, the insect moults or sheds its skin, the moult being almost a complete replica of the insect. Nymphs cast their skins five times in all, and, in houses which are or have been infested, the discarded skins often furnish evidence of extensive breeding. Such moults are generally found in small masses behind skirtings. When the insect moults, the skin covering the head splits first, this division being carried along down the remainder of the body.

Under the most satisfactory conditions of temperature and given an abundance of food, maturity may be reached in ten weeks, when reproduction begins. After each moult, the colour of the insect gradually deepens from a pale dun colour to the chestnut or dark brown of the mature insect, while a gradual increase in size is also effected. It is not, however, until the final stage that the wing pads appear, and even then these are not very obvious. The short hairs of the body are more scanty than in the adult, while there is no differentiation of sex until the final moult has been completed. In the first stage of development, one meal is required before the insect is ready to moult, but thereafter one full meal between two successive moults is usually sufficient. Moulting may be delayed if food is scarce and temperatures are not suitable.

(3) THE ADULT. The adult female lives, on an average,

from six to eight months, but nothing definite is known regarding the life of the adult male. Mating usually takes place after a full meal, but this is not always the case, while, as a necessary preliminary to laying, the female requires a feed of blood. When fed, the body is distended almost to bursting point. The body is flat when unfed and often almost as thin as paper. The flat structure of the body allows the bug to penetrate cracks and crevices in walls, woodwork and furnishings.

The interval which elapses between the laying of the egg until the adult stage is reached varies, but under favourable conditions may be as short as six weeks. The average period in this country is about ten weeks. Scarcity of food and other circumstances unfavourable to development may extend the period to a year or even longer.

Bed-bugs and Disease. When an individual receives a bite from a bed-bug a minute red point is left on the skin where the proboscis has been inserted. Within a few hours a small area of erythema appears around the puncture. The act of feeding or searching for food may cause no discomfort whatsoever, except to those persons with sensitive skins. In most instances the annoyance caused is slight. Papules usually appear at the site of the puncture after a few days and may remain for a week. If the punctures are numerous, the local reaction, which varies in different individuals, may be followed by a general febrile disturbance. Persons living in infested property readily acquire immunity to bites. In children, swelling of the face and the appearance of wheals on various parts of the body have been reported following numerous bites, to which must be added the

restless nights resulting from such invasion. Young children are most severely affected.

Although often suspect, bed-bugs have not yet been definitely convicted of carrying disease, although it is possible that, in some cases, infection may be carried by them from one person to another. On the other hand, the insects may cause actual ill-health from lack of sleep due to skin irritation. Although recent investigations tend to acquit bed-bugs of any serious responsibility for the spread of disease, their appearance in any property is usually a sign that immediate steps should be taken to improve the existing standard of sanitation and reduce overcrowding.

Experimentally, bed-bugs have been shown capable of acting as " carriers " or intermediate hosts of sleeping sickness, infectious jaundice, malaria, relapsing fever and yellow fever. They may also act as mechanical carriers of plague and leprosy. As already indicated, however, proof that such diseases are normally carried by bed-bugs has never been forthcoming. Apart from their bites and the suspicions attached to the insects as a means of spreading disease, bugs are objectionable for the following reasons :—

(1) They often give rise to objectionable odours in infested houses.
(2) They deposit filth behind woodwork, on pictures, and on furniture.
(3) They disfigure walls and ceilings, due, in many cases, to the habit of the occupiers in destroying the insects whenever seen.
(4) Damage is often done to the property during disinfestation.

Dissemination. Bed-bugs may be readily disseminated by any of the following means :—

(1) Removal of infested furniture.
(2) Removal of furniture in infested vans.
(3) Purchase of second-hand furniture.
(4) Migration of bugs from room to room and from house to house.
(5) Use of old building materials.

(1) Removal of Infested Furniture. The removal of infested furniture from old houses to new premises is probably by far the most potent factor in the spread of bed-bugs. What is not always realised is the fact that new furniture as well as old may disseminate these pests. New furniture on which hire-purchase payments have become overdue is often returned to furniture companies to be quickly resold, supplying a ready means whereby bugs may be disseminated. Furniture stored in depositories may also become infested. In the past, considerable quantities of furniture were removed from infested property direct to new houses without any attempt being made to disinfest the articles. Contact insecticides are of little use in freeing furniture from the bed-bug and its eggs unless repeated doses are given, resort to gaseous fumigants being considerably simpler and more effective. Most districts now fumigate the furniture of tenants being rehoused prior to its removal to new premises.

(2) Removal of Furniture in Infested Vans. There can be little doubt that the infestation of furniture has often occurred as a result of the verminous condition of the removal van. If these vans have been used for the removal of verminous furniture, the insects which

drop off will remain in the van and will infest subsequent loads of furniture. It is obvious that, unless these vans are submitted to disinfestation, clean furniture may become contaminated. Disinfestation of all vans between each removal should therefore be compulsory. The wrappers used by removal contractors are also often a source of infestation.

(3) Purchase of Second-hand Furniture. Second-hand furniture and bedding are a potent source of infestation, being often bought from or exchanged between neighbours, quite apart from the transactions which take place between dealers and their customers. The most practical method of reducing this risk is by the education of tenants and dealers, as it is obvious that these insects may be widely disseminated by furniture becoming infested in second-hand dealers' premises. Boxes and suit-cases are also a source of infestation. Particularly is this the case among the seafaring population whose suit-cases have become infested and who may transfer bed-bugs from ship to shore, and *vice versâ*. Clothing, particularly if second-hand, may also cause trouble, while returned laundry may also be a source of infestation. In one or two instances bugs have been found in straw fruit-baskets.

(4) Migration of Bed-bugs. As already noted on p. 21, bed-bugs, although unable to fly, are capable of travelling considerable distances in search of food. They are able to pass from one house to another, travelling along walls, pipes and gutters. There is definite proof that bed-bugs can and do migrate from an infested building during demolition to other premises, thus causing further infestations.

(5) Use of Old Building Materials. This is a likely

source of infestation. During the demolition of slum property large quantities of old materials are sold for subsequent use. Old timber obtained through such a channel and introduced into new houses may give rise to considerable trouble. Infested timber may also be sold and broken up to to be resold as firewood, while the use of such wood for the construction of garden sheds, etc., may cause infestation. In many cases such timber is stored in the owner's house until ready for use. It is advisable in the case of slum clearance schemes to fumigate the premises before demolition, while the use of the blow-lamp on all old timber is a practicable and valuable safeguard.

Control and Eradication. Although bed-bug infestation is a problem of very long standing, little organised effort has been made to overcome it until recent years. If houses are to be maintained in a sanitary condition, insect pests must be rigorously suppressed. Because of the infestation which may occur when old houses are exchanged for new, this problem requires particular attention. New housing estates may quickly become infested with these insects unless strict supervision is maintained and the appropriate preventive measures continuously applied. Much of this trouble is caused by the ignorance of occupants as to how to prevent infestation and, what is perhaps more important, how to deal with premises when infestation has occurred. Without a thorough knowledge of the insect and proper supervision, premises quickly become infested, when the clearance of the vermin assumes expensive proportions. The elimination of the bed-bug harbourages in new houses when erected, dealt with in Chapter V, plays an important part in the control of infestation.

It is obviously important that the presence of eggs should be detected even when isolated from colonies of insects, in order that they may be destroyed. The eggs of the bed-bug may be destroyed by suitable concentrations of gaseous fumigants.

The breathing system of the bug consists of a series of spiracles lying along each side of the body, a normal feature of all such insects. In all probability the lethal effect of contact insecticides and of lethal gases is due to the penetration of the tracheæ and the fine branches of the respiratory system which lead from the spiracles. Hydrogen cyanide may be said to kill bed-bugs and their eggs by reason of the hydroscopic nature of the gas. This probably explains why well-fed bugs are more readily killed than starved ones, and also its properties as an ovicide. Bugs do not readily drown in water, as the natural oiliness of the insects' bodies and the constriction near the opening of each of the spiracles prevents the entrance of fluid. For this reason insecticidal powders cannot be depended upon as a means of destruction, while it is hopeless to attempt to destroy bugs by means of insecticides possessing a watery base. Insect powders containing Pyrethrum or Rotenone have a neuro-muscular action on bed-bugs.

It is not proposed to detail here the various fumigants and contact insecticides, but rather to consider briefly the various methods which may be used to assist in controlling and eradicating these pests. Bed-bugs prefer contact with rough surfaces and such places as afford warmth and undisturbed conditions together with darkness, although the latter is not essential. Smooth surfaces exert a repellent action upon the insect. As already mentioned, their habitats are many and varied.

For this reason active measures adopted must be designed to deal with all types of harbourage. These methods may be classified as follows :—

(1) Fumigation.
(2) Contact insecticides.
(3) Miscellaneous methods.

(1) FUMIGATION. There is no doubt that *hydrogen cyanide* in one of its many forms is the most efficient fumigant known for the destruction of bed-bugs. Abroad it has been used with considerable success, but in this country, owing to the possibility of accidents, several of which have occurred, its use in inhabited houses has been somewhat restricted. Although used with considerable success on new housing estates in all parts of the country, the greatest care is necessary if accidents are to be avoided. It should only be used by responsible, highly trained persons, who should possess a comprehensive knowledge of its properties.

Sulphur dioxide is commonly used for dealing with infested property, and many authorities state that this is very effective. It possesses the disadvantage of adversely affecting fabrics and metals, particularly in the presence of moisture. Fumigation with sulphur dioxide should be repeated within three weeks in order to destroy any larvæ which have hatched out since the previous treatment, as its powers of penetration are not so satisfactory as those of hydrogen cyanide.

Ortho-dichlor-benzene is very useful and effective, but should only be used in empty houses. Its use in occupied property is now prohibited by the Ministry of Health.

Formaldehyde is the standard method adopted by the Army Medical Services, but is not to be recommended.

Ethylene oxide has been extensively used in the United States of America and has been tried in this country in the form of "Etox." It is less toxic to man than hydrogen cyanide, and, whilst it is also less toxic to bed-bugs, it is also toxic to human beings, and it is an efficient fumigant under favourable conditions. At present it is an expensive method of fumigation, but if the demand increased, it is reasonable to assume that the cost would be proportionately reduced.

Heavy naphtha has now come to the fore as a means of ridding property of vermin. It has been used with considerable success, is not toxic to man, although heavy concentrations demand the use of a gas mask, and is cheap. Further consideration of this important material will be found on pp. 128–130.

(2) CONTACT INSECTICIDES. It is a simple matter to devise a mixture of chemicals which will destroy bed-bugs when the mixture is sprayed directly on to the insects. There are innumerable insecticides on the market which will kill by contact, and all claim to be infallible toxic agents for bed-bugs, a claim which can by no means always be substantiated. Some of the liquids are said to give off a vapour which is toxic to the insects, while the vapour of others is claimed to be sufficiently irritating to the insects to induce them to leave their harbourages and come into the open, where they may be sprayed by the direct method. There is reason to believe that this latter claim is true and that the bed-bugs do leave their hiding places and expose themselves to the direct action of the liquid. At the present time, very little is known as to the toxic effect exerted by different chemical substances on bed-bugs,

but constant experiment will no doubt evolve the ideal contact insecticide.

(3) Miscellaneous Methods. As the bed-bug may be killed by a short exposure to a temperature of 120° F., *superheating*, as the method is termed, has been carried out with some success in North America. *Steam* has also been used for this purpose in suitable situations. Certain *deterrents* have been tried, and might with advantage be subjected to further investigation. Various *washing emulsions* and *insect powders* have been used with varying degrees of success. Powders would, however, appear to have little to recommend them. The combined use of *soap and water*, together with frequent visiting and the education of tenants, is said to have achieved satisfactory results in Glasgow.

For the disinfestation of bedding, *toxic gases* may be used, but, owing to the absorption of such gases by the material, their use for this purpose cannot be recommended. *Steam disinfection* is, without any doubt, the best and most satisfactory method of treating bedding, while experiments have shown that *heavy naphtha* can also be successfully used for this purpose.

It should be remembered that absolute reliance cannot always be placed on fumigants and contact insecticides alone. In conjunction with these, the tenants should be instructed in the principles of cleanliness, without which re-infestation will almost certainly occur at a longer or shorter interval.

CHAPTER III

THE FLEA

Introductory. While the bed-bug cannot be definitely convicted of being a carrier of disease, no such doubt exists regarding the flea. Apart from the pain and discomfort resulting from the bite of this insect, fleas are known to be the means of transmitting a number of infectious diseases, which have resulted in considerable loss of life.

Fleas belong to the order *Aphaniptera*. They are small, wingless insects and differ from bed-bugs and lice in that they are flattened from side to side and not from above, while they also undergo complete metamorphosis. The mouth of the flea is adapted for piercing the skin and sucking blood, there is no neck between the head and the thorax, while they also possess a curious dorsal sense organ situated on the posterior section of the abdomen.

All adult fleas are parasites of mammals and birds. They live on their hosts, among hair and feathers and in clothing, their compressed bodies, long legs and hard, smooth exterior affording them considerable advantages over other forms of insect life. They obtain their food by sucking the blood of their host, both male and female fleas being alike in this respect. Each animal species usually possesses its own specific type of flea, although certain types of fleas feed on a number of hosts. The

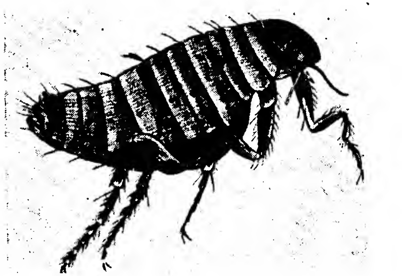
latter type, unlike many parasites, may pass from host to host with complete indifference. Thus, cat and dog fleas readily attack man, while rat fleas pass to other animals and also to man in the absence of their own host.

In this country some fifty species of fleas are to be found. The human flea, *Pulex irritans*, is exceedingly common. The flea found on dogs is known as *Ctenocephalides canis*, while the cat flea is *Ctenocephalides felis*. The normal rat flea in temperate climates is *Ceratophyllus fasciatus*, the plague flea being *Xenopsylla cheopsis*. The remaining species, although of biological interest, are not so important from a sociological standpoint.

Structure. The *head* of some fleas, if viewed from the lateral aspect, is rounded behind, while above the mouth is a notch or tooth which assists the flea to emerge from its pupa. In other types which adhere firmly to their hosts, the head may be angular in front. The common flea possesses one or at most two bristles situated on the posterior margin of the head, while the plague flea exhibits a row of these bristles. *Eyes* may or may not be present. If eyes are present and the comb is absent, the insect may be either a human or a plague flea. This comb of bristles serves to distinguish the human and the plague fleas from other species. *Ceratophyllus fasciatus* or the rat flea possesses eyes and one comb, while the dog and cat fleas possess both eyes and two combs. Above the eyes lie the *antennæ* in protecting grooves. The *mouth opening* is anterior and ventral in position. At each side of the mouth is a triangular, hard, chitinous flap, while the upper lip is long and narrow. The flea possesses *mandibles* which are used for piercing the skin

of the host. The head is attached to the thorax without any intervening neck, lateral movement being thus impossible. It will thus be seen that the flea cannot change its field of vision without altering position, since the body is adapted for forward movement only.

The *thorax* is composed of three segments, the exterior of which is hard and chitinised. The flea has three pairs of hair-covered *legs* attached to the thorax, these legs being long and well adapted for jumping. Each leg possesses a pair of strong *claws*. The front legs of the human flea are plain, while a black, T-shaped mark is present in the case of the plague flea. This serves to distinguish the two species.



By courtesy of Associated Fumigators Ltd.

FIG 10. Flea (*Pulex irritans*).

The *abdomen* is based solidly on the thorax and consists of ten segments, again protected by a chitinised exterior. Hairs, bristles and spines are found all over the external surface of the flea, some appearing in rows, others as separate groups. All the bristles of the flea point in a posterior direction to facilitate rapid progress through the hair, feathers or fur of the host. These insects possess a large *heart*, while breathing is carried on by means of ten pairs of *spiracles*, two pairs being situated on the thorax and eight on the lateral surfaces of the abdomen.

The *alimentary tract* of the flea is important if a true

knowledge of the part played by these insects in transmitting disease is to be obtained. The flea is provided with a *pharyngeal pump* continued as the *gullet* which, in turn, leads on to the "*gizzard.*" This is a pear-shaped structure provided internally with spines, the function of which is to prevent the contents of the stomach being vomited back during the digestive processes. On each side of the stomach are situated a pair of *salivary glands*, the contents of which are delivered by a *salivary pump*. When a flea bites, the skin is pierced, the actual aperture being effected by the mandibles. The flea thrusts downwards with all its weight, elevating the abdomen and hind legs. Both pharyngeal and salivary pumps immediately become active, the latter pouring out saliva which is injected into the wound and so finds its way into the blood of the host. In the meantime, the pharyngeal pump is drawing up blood mixed with saliva. This is passed to the stomach for digestion.

Life History. Fleas pass through the following stages before they appear as adults :—

(1) Egg.
(2) Larva.
(3) Pupa.
(4) Adult.

(1) EGG. The eggs of the flea are small, smooth, but relatively very large bodies, oval in shape, with a waxy, translucent appearance. They are not glued or attached to the host but are deposited in dirt where the larvæ feed. They can be readily distinguished by the naked eye. The eggs hatch out in from two to ten days, eyeless and legless larvæ emerging. These are yellowish, wormlike creatures covered with bristles.

(2) Larva. The larva breaks the egg-shell by means of a special tooth. It is approximately 4 millimetres long when full grown and possesses a well-developed head to which are affixed single-jointed antennæ. It also has fourteen segments, made up of the head, the thorax (three segments), and the abdomen (ten segments). The food of the larvæ is found in the *débris* of the host's nest or in houses where the eggs are laid. Half-digested blood which has passed through the parent flea's body is also a means of sustenance. Larvæ are extremely active creatures, moving with great rapidity by means of bristles which encircle each segment of the body. When fully grown, the larvæ surround themselves with silken cocoons, which are spun from their own saliva. Pieces of *débris* and dust adhere to the cocoons, rendering their detection amongst dust and dirt exceedingly difficult.

(3) The Pupa. The larva rests for some time in the cocoon, but eventually casts its skin and becomes a pupa. After a few weeks the pupa gives rise to an adult which may lie quiescent for some long time before beginning its active life. It is recorded that the young adult fleas will lie dormant in the cocoons in deserted rooms until such rooms become inhabited. Then, as they are extremely sensitive to vibrations and mechanical disturbances, they will emerge. This is probably the cause of the sudden appearance of fleas in what have appeared to be vermin-free houses. This period of resting is reduced when hosts are numerous and conditions of temperature and moisture are suitable.

(4) Adult. Newly emerged fleas can live for some time without food. The male flea emerges from the pupa first, followed by the female, which requires a meal of blood before any eggs can be laid. The human flea

possesses a life cycle of four to six weeks from egg to adult in this country. The life cycle of the rat flea in India is some three weeks, but in this country would probably be longer.

Characteristics and Habits. The adult flea differs from its larva in that it exhibits many degrees of attachment for its host. While some infest one particular animal, others infest many hosts. In feeding, the same holds good. The method of feeding varies with the species of flea. One type will bite often and take short feeds. while another will only feed at longer intervals. The fact that fleas will transfer their attentions from one host to another is important from a public health point of view, as this transference assists the spread of disease.

It is difficult for fleas to walk on smooth surfaces, their usual mode of progression being a series of runs or jumps. They bury themselves in hair, fur or feathers, shunning daylight and being attracted by warmth. If disturbed they are said to sham death, resting with their feet tucked firmly against the body. Their jumping powers are of no mean order. Vertical jumps of 7½ inches have been reported, with jumps of 13 inches in a horizontal direction.

Fleas are disseminated in a variety of ways. The eggs, which are frequently laid on the host, may be scattered before the animal goes into its nest. Fleas will leave the body of a dead host as the carcase begins to cool, while hosts such as rats and mice are carried from port to port by shipping. The adult flea is not much affected by changes in humidity, its length of life being principally determined by the temperature, always provided that blood is available for feeding. The larvæ are easily

killed by low humidity, and it is probable that, where temperature is high and humidity low, fleas may become rare.

The human flea feeds also on pigs and on the badger. In houses and piggeries the insect breeds in crevices in the floors, under carpets, in straw, and in dust wherever this is allowed to accumulate. The female may lay up to 450 eggs during its lifetime. The adult can live without food for long periods, but the length of life is dependent upon temperature and available supplies of food. If regularly fed, it may live for eighteen months. Cat, dog and rat fleas lay their eggs on their particular host. The eggs may, however, fall out of the animal's fur or hair into crevices in the floor or into the animals' beds, where they may subsequently hatch out.

Adult fleas feed at least once each day and sometimes at much more frequent intervals. The frequency of biting is due to their disturbance when feeding and to their subsequent attempts to puncture the skin again in order to continue this process. Fleas will feed to repletion and, when gorged, will continue to feed, passing unaltered blood from the stomach.

Fleas and Human Disease. The bite of the flea is extremely annoying to many people, although the effects vary greatly according to the flea implicated and the person attacked. While some people seem to be immune, others are very susceptible and suffer tortures even from a single flea. In the process of biting, the flea injects saliva into the wound, which produces irritation and itching, a red spot showing on the skin. This irritation is generally of brief duration, although in some instances it may last for a considerable period, the application of soothing lotion becoming necessary.

It is, however, as a direct vector of disease that the flea assumes vital public health importance. Eleven varieties of this insect may transmit disease, while five common British species are known to do so under favourable conditions. The most important from this point of view is the *Xenopsylla cheopsis*, which is occasionally introduced into these islands. This, with other plague fleas, is generally found on rats, more especially the black rat. Its ability to transmit plague renders it dangerous, particularly as regards the transmission of bubonic plague. Plague, the causative organism of which is *Bacillus pestis*, is epizootic in rats. A heavy mortality in rats always precedes an epidemic of plague, which may take any one of three forms:

(1) Bubonic. This is the least fatal and is transferred from rat to man and again to rat from man.
(2) Pneumonic. This is practically always fatal.
(3) Septicæmic. This is also practically always fatal.

Plague is one of the major scourges of the human race and frequently assumes epidemic form, killing large numbers of people. Bubonic plague is transmitted from rat to man and *vice versâ* by means of the flea. When the flea imbibes the blood of a person suffering from plague, colonies of plague bacilli grow in its stomach and eventually block the entrance. Although the flea in such a case cannot pass fresh blood into the stomach, it still tries to do so. This additional blood stops the pumping action of the pharynx, and some of the infected blood is forced back into the wound made by the flea. Such infected fleas live for a considerable time and are a constant menace to all persons with whom they come into contact. Infection is also carried by excreta.

Plague is essentially a disease of rats and other rodents, and man becomes infected through infected fleas. The two rats concerned are :—

(*a*) The black rat (*Rattus rattus*).
(*b*) The brown rat (*Rattus norvegicus*).

As the plague fleas inhabit the bodies of rats, the control of plague depends upon the control and destruction of rats and their parasitic fleas. Even though outbreaks of plague are not common in this country, it should be remembered that the menace will continue to exist so long as the control of rats and their fleas is neglected. This risk has, of course, been reduced since the inspection of shipping became more efficient in all large seaports, while, in addition, modern ships are so constructed that little harbourage is afforded to rats. The deratisation of ships under the International Convention of Paris, 1926, has considerably decreased the danger from rats and their fleas.

Control Measures. Fleas become attached to the human body in different ways, either accidentally, owing to a temporary cause, or from some more permanent source. *Repellents* such as *iodoform, naphthalene, oil of pennyroyal* or *oil of eucalyptus* may be used with varying results. Beds should be kept away from walls and bedding should not be allowed to hang near the floor. In addition, the legs of the bed should, if the room is infested, stand in dishes of water.

The chief sources of fleas in the home are :—

(1) Want of strict cleanliness. Among the most common defects may be mentioned dusty corners, uncleaned rugs and carpets, dusty

cracks and crevices, greasy kitchens, dirty bathrooms, cupboards used as storeplaces for dirty clothing, cellars littered with rubbish or filth. In such places, the eggs of the flea may hatch undisturbed and the larvæ obtain sufficient food and moisture.

(2) Unchecked breeding of fleas in stables, poultry-runs and outhouses.

(3) Entrance of cats, dogs, rats and mice, which are all carriers of fleas, into domestic premises.

The control of fleas means the destruction of their hosts and the destruction of their breeding centres. Rats and mice should be trapped and poisoned until the premises are clear of such vermin. Rat holes should always be disinfested, as the larvæ will develop in the nests and in the holes. Cats and dogs should be washed with a good carbolic soap containing some insecticide. A 3 per cent. solution of *creolin* (four tablespoonsful to each gallon of water) may be used. This should be applied to the coat of the animal in a warm condition, the animal being thereafter washed with soap and water. Insecticidal powders may also be used. *Powdered naphthalene* or *pyrethrum powder* may be dusted into the animal's coat. This stupefies the fleas, after which they may be brushed out and burned. *Derris powder* may also be used. This should contain 2 per cent. of *rotenone* mixed with 40 parts by volume of French chalk, the mixture being well rubbed into the animal's coat.

In domestic premises, the furniture should be removed and treated with some liquid insecticide out of doors, afterwards being carefully examined for the presence of

the insects, their larvæ or eggs. The edges of carpets and skirtings may be sprayed with turpentine or naphthalene, while this liquid may also be applied to wooden floors. There is, however, considerable danger attached to the use of this liquid, while, in addition, it will not sterilise the eggs. Carpets should be taken out of doors, sprayed and beaten. The floors should be washed and crevices carefully filled up. Many types of powders are of considerable use. *Flaked or powdered naphthalene* is cheap, not very inflammable and easy to obtain. Naphthalene should be scattered over the floors of infested rooms and left for twenty-four hours. The floor should afterwards be swept to remove the dead fleas. *Sodium fluoride*, an extremely poisonous powder, may be used if desired in place of naphthalene, great care being taken in its employment, while *derris* and *pyrethrum powders* are particularly good if fresh. After treatment with any powdered chemical, the floor should be washed with a 2½ per cent. solution of *formalin.* Clothing and bedding should be sprayed and afterwards disinfected by steam. Cellars should be sprayed with *crude kerosene.* Fumigation with any of the following gases may be employed :—

(*a*) Sulphur dioxide. Four pounds per 1,000 cubic feet for six hours will kill larvæ and adults.
(*b*) Formalin vapour.
(*c*) Carbon disulphide. Very dangerous to use owing to risk of explosion.
(*d*) Hydrogen cyanide. Also very toxic. Two ounces per 1,000 cubic feet of liquid or gaseous hydrogen cyanide are required. It must once again be emphasised that great care is necessary in using this material.
(*e*) Naphthalene. Five pounds of flaked or powdered

naphthalene for each 1,000 cubic feet for twenty-four hours are required. High temperatures are essential when this material is used, in order to assist diffusion of the gas.

It should be remembered that, if success is to be attained by the use of gaseous fumigants, the rooms must be effectively sealed.

Lethane, heavy naphtha, or one of the many dependable proprietary liquid insecticides, such as Ris, Pyagra and Zaldecide, may also be used with good effect.

Outbuildings, stables and poultry-houses should be properly renovated and cleared of all rubbish. The buildings can be treated by one of the methods already specified for the disinfestation of houses. The walls and floors may be washed down with a 3 per cent. solution of *creosol* or with a *kerosene emulsion* made with 3 parts of soft soap melted by heat in 15 parts of water to which hot liquid, 70 to 100 parts of kerosene, have been gradually added. The gradual addition of the kerosene is essential if a suitable emulsion is to be obtained. For rat holes, calcium cyanide or "Cyanogas" should be blown in and the holes blocked after treatment has been completed. This method is said to be effective up to a distance of 15 feet. Alum added to limewash is also said to be effective.

It cannot be too often emphasised that strict cleanliness is the main desideratum in the prevention of flea infestations.

CHAPTER IV

THE LOUSE

Introductory. Lice belong to the order of insects known as *Anoplura*, and undergo incomplete metamorphosis. They are small, entirely wingless insects whose only food is the blood of mammals and birds. Young lice do not differ greatly from their parents and, like them, require sustenance from a suitable host. The eggs must be laid near the skin of the host in order to secure a suitable temperature for incubation. The entire life cycle of the louse is bound up with its host, this fact being of great assistance when the question of destruction has to be considered.

Types of Lice. Man may become infested with three types of lice, as follows :—

(1) The head louse (*Pediculus humanus humanus*).
(2) The body louse (*Pediculus humanus corporis*).
(3) The crab louse (*Phthirus pubis*).

Other mammalian lice, of which there are some six genera, may stray to man, but do not survive in their new quarters. The head and body louse are biological races of the same species ; as they are able to interbreed they are not distinct species. Head lice often appear on the body, but body lice are extremely rare on the head. All three types are blood suckers.

(1) THE HEAD LOUSE. This species lives, as might be

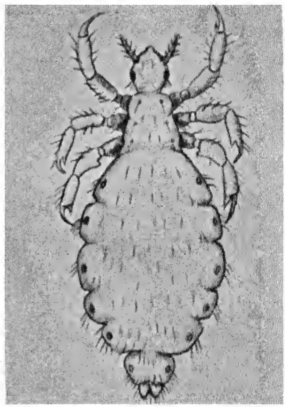
expected, principally on the head, cementing its eggs amongst the hair. It is most commonly found on the back of the head and above the ears. It is usually smaller than the body louse, while the male is smaller than the female. It is greyish in colour, the margins of the abdomen being darker and in some cases almost black. In the male, the abdomen is rounded at the posterior extremity, while that of the female possesses a deep cleft. The head louse is more active than the body louse, while it feeds oftener and more sparingly.

The *head* is rounded in front and rather bluntly pointed behind. Two *antennæ* are fixed to the head at a constriction which, posterior to this point, bulges sharply and narrows to the *neck*. This latter is short, although it permits of considerable movement. The antennæ are short and possess five joints. The *eyes* are prominent and heavily pigmented, but possess no facets. The head also exhibits teeth-like projections which anchor the mouth to the skin when the louse feeds. Complicated muscles are provided which operate the *pumping chamber of the pharynx*. When the skin has been punctured, the piercers are brought forward and pass into the skin together with the *salivary duct*. Saliva is poured into the wound, this secretion possessing the property of preventing coagulation of the blood. Blood is pumped to the heart and through the body by the muscular pharynx with great rapidity.

The *thorax* resembles a consolidated box widened towards the rear. The six *legs* are attached to the thorax which possesses a single pair of *spiracles* situated on the middle segment. The legs are stout and well designed for clasping and holding, each leg being provided with a *claw*.

The *abdomen* consists of nine segments, seven of which can be counted. The edges of the segments are chitinised. The abdomen also possesses six pairs of *spiracles.*

(2) THE BODY LOUSE. This insect is found principally on the body, the eggs being laid on the clothing and occasionally on the body hairs. It resembles the head louse in almost every respect, except that it is slightly larger and lighter in colour, the antennæ are more slender, and the indentations in the body are less pronounced. It is also shorter than the head louse. Its chief distinguishing features lay in its habitat and the fact that its eggs are laid on the clothing rather than the hairs of the body.



By courtesy of Associated Fumigators Ltd.

FIG. 11. Body louse.

(3) THE CRAB LOUSE. The crab louse possesses several distinctive features which distinguish it from head and body lice. It is much smaller, the body being square, while the head is blunt. The legs are large and strongly developed, the spiracles are prominent, while it is an extremely inert insect. It is usually confined to the pubic and the perianal regions, although it has been found attached to hairs in other parts of the body, but never in the head. Cases have been recorded, however, of this insect being present in the beard and moustache. It differs from the head and body louse in that it does not move about in search of food, but

remains for a considerable period in one spot, gripping the hairs of the body with its claws.

Characteristics of Lice. There are certain characteristics common to all types of lice. When starved, they will gorge to excess, and those present on the body feed whenever hungry. They usually feed at night when the host is at rest, occupying three to ten minutes for the purpose, although instances have been reported of lice sucking intermittently for two to three hours. Young lice feed immediately they are hatched, continuing to feed at varying intervals throughout life. Excreta is voided, often very profusely. This is important when the method of transmitting pathogenic organisms is considered.

Although lice are generally found attached to their host, they have been reported as wandering about rooms, crawling up walls and on the upholstery of railway carriages and other conveyances. Warmth renders them exceedingly active, and below is shown their activity as compared with temperature.

0° C. Immobile.
10° C. Slow movement shown.
20° C. Fairly active.
30° C. Very active. This is approximately the temperature of their normal habitat (this does not apply to crab lice, which are normally inactive).
38°–40° C. Wildly active and soon die from exhaustion.

The thermal death-point of lice is 112° F. for a period of one minute. They are very active on persons suffering from fever, migrating from the patient in large numbers. When a person dies, the lice soon abandon the body and scatter. They are exceedingly gregarious, tending to congregate in large numbers. They breed very rapidly,

and it has been calculated that a single female louse will, in eighty days, produce nearly 1,000 descendants. In temperate climates lice are much more numerous in winter than in summer.

The crab louse exhibits entirely different characteristics. It feeds intermittently for hours or days and rarely removes its mouth parts from their position on the host, only withdrawing them when moulting. It defæcates frequently, voiding intermingled blood and waste material. As might be expected, this soon renders its surroundings filthy.

It is reported that lice can live for ten days at 41° F., while they can withstand dry cold to a limit of 10° F. The insects and their eggs are killed by a temperature of 62° C. if applied for five minutes. Egg-laying does not take place when the louse cannot feed, while the process also ceases at temperatures below 70° F. The eggs will not hatch at a cool, constant temperature of 68° F. The crab louse cannot exist for long periods away from its host.

Life History. In considering the life history of lice, due regard must again be paid to the three types of insect :—

(1) The head louse.
(2) The body louse.
(3) The crab louse.

(1) The Head Louse. Some twenty-four hours after emerging from the last nymphal skin, the adult females begin to lay eggs, the daily average being six or seven. The total number of eggs produced by one female during life is not correctly known, but is certainly well over 100. The eggs, commonly known as "nits," are very small,

but can be detected with the naked eye. They are cemented to the hairs, the cap being directed away from the base of the hair. If retained at body heat, they will hatch in eight to nine days. So far as is known, the eggs never hatch before the eighth day or at temperatures below 22° C., while at low temperatures hatching may occupy any period up to several weeks. When the nymph is ready to emerge, it employs a novel method to open the cap which seals off the upper portion of the egg. It sucks in air which is propelled through to the back of the egg, until the cushion of air so obtained exerts sufficient pressure to open the cap. The forepart of the nymph is forced out, when continuous pumping gradually ejects it from its shell. Oil applied to the egg prevents the introduction of air and the egg will not hatch.

The nymph begins to feed within a few hours, and moults three times before it reaches the adult stage. The adults live for approximately thirty days. The insects evacuate a reddish-black excreta during growth. The life cycle at body heat is approximately as follows :—

Egg stage	8 days
First nymphal stage . .	4 ,,
Second nymphal stage .	3 ,,
Third nymphal stage .	2 ,,
Adult	14 ,,
Total life	31 ,,

The length of the life cycle may be prolonged by lack of food or low temperatures.

(2) THE BODY LOUSE. The life history of the body

louse is very similar to that of the head louse. The female lays eggs at the rate of approximately ten per day, up to 300 being deposited during life. The eggs are usually laid on woollen materials, in the seams and folds of clothing, and on the hairs of the chest. The eggs hatch in eight to nine days, while the entire life cycle from egg to egg may be as short as sixteen days at the optimum temperature of 35° C. The centres ot infestation are the clothing, especially at the back of the neck, shoulders, waist, wrist, the outside of the buttocks and the fork.

(3) THE CRAB LOUSE. The eggs of the crab louse are deposited on the hairs of the body, close to the base, up to twenty-six eggs being laid by one female. They hatch in seven to eight days. The nymphs cling to a single hair, but the adults anchor themselves to two hairs, grasping one on each side. The life cycle is approximately as follows:—

First nymphal stage	.	5 to 6 days
Second nymphal stage	.	9 to 10 ,,
Third nymphal stage	.	13 to 17 ,,

The complete life cycle from egg to egg varies between thirty-four and forty-one days. Nymphs or adults cannot survive above two days when removed from their hosts. Crab lice never move more than 2 inches throughout their entire life, while such movement is always made in a sideways direction. The female louse begins to lay eggs within one or two days of reaching the adult stage.

Dissemination. Head and body lice are very active and can attach themselves to hair and clothing, while they can survive for a maximum of ten days without

food. They can be disseminated from head to head by direct contact, since lice, clinging to hairs, readily move to another warm body close at hand. Caps or hats worn by infested persons and hung in close contact with one another, as prevails in school cloakrooms, may also result in rapid spread. The hair of infested persons may fall on the clothing of other individuals, when infestation will occur. Infested persons are constantly scratching, and in this way hairs to which eggs are attached often drop on to the seats and cushions of public conveyances and places of entertainment. Infested clothing, bedding and brushes also assist in disseminating lice.

The crab louse is disseminated by actual contact with an infected person, or by hairs to which eggs are attached being scattered on to clothing. They may be spread by the use of common towels in gymnasiums, dormitories and sports pavilions. If the host scratches, the eggs or lice may drop on to clothing, bedding or the seats of public conveyances. Under crowded conditions, a single infested person may distribute crab lice throughout an entire group of individuals.

Conditions conducive to self-neglect and the tolerance of dirty bodies tend to favour the multiplication of lice if once they obtain a foothold. Head lice are commoner on women and children, while men become more readily infested with crab and body lice. All three may, however, exist on the same host.

Lice and Disease. The head and body lice affect the host in two ways, *i.e.*, by means of the *bite*, which may exert some effect upon the body, and by the *transmission of pathogenic organisms.*

While some people are immune to the bite of the louse,

others are highly susceptible. The bites produce minute hæmorrhagic spots which are most frequently found on the neck, back, breast and abdomen. These spots are often accompanied by urticaria and intense itching, while scratching of the affected part readily leads to secondary infection. As lice most frequently attack their hosts at night, loss of sleep and restlessness often result. This may be the cause of anæmic conditions, especially in children, and is obviously not conducive to normal health.

Lice have been proved to be carriers of infectious disease. *Typhus fever* is carried by lice. The disease is spread by the bite, while the entrance of the excreta of infected lice into cuts and abrasions is also a means of spreading the disease. If an infected louse is crushed and rubbed into a cut, infection will almost certainly result. The disease develops in seven to eleven days after a louse has fed upon an infested person. *Relapsing fever* is also carried by lice, the disease developing five days after inoculation. This disease is spread by the blood of an infected louse when the insect is crushed near a cut or abrasion, and is not caused by the bite or fæces. *Trench fever*, so prevalent during the Great War, is another louse-borne disease. Infection is generally produced by the excreta of the insect. The excreta is virulent for at least four months, the inhalation of dusty excreta being sufficient to cause infection. Skin diseases of the head, such as *impetigo*, *favus*, and *pityriasis*, are also initiated by lice, while *pustular dermatitis* and *pigmentation of the skin* may also result from heavy infestations. By the constant poisoning of the system through scratching, general suppurative processes, developing in some cases in septicæmia or

pyæmia, may be set up throughout the body and, in extreme cases, death may occur.

The crab louse is not known to be the means of transmitting any disease.

Control Measures. The control and destruction of lice is made more complex by the fact that, although they may have many disseminating hosts, there is never a local centre of distribution as is the case with bed-bugs or fleas. The problem of control resolves itself into the employment of the following measures :—

(1) Prevention of infestation.
(2) Cleansing of infested persons.
(3) Treatment of clothing and bedding.

(1) PREVENTION OF INFESTATION. Strict personal cleanliness is the best method of preventing infestation. That is a canon which should in no circumstances be neglected. If the simple rules of personal hygiene are followed, no person should become infested. These rules may be briefly stated as follows :—

(*a*) All infested persons and their effects should be avoided.
(*b*) Overcrowding should be avoided.
(*c*) A bath should be taken at least weekly, when plenty of hot water and soap should be used and the body rubbed dry with a rough towel.
(*d*) Underwear should be regularly worn and changed weekly.
(*e*) The head should be frequently washed, combed and brushed at least once daily, and kept clean at all times.
(*f*) Unclean bedding should be avoided, particularly blankets. This is most important when travelling.
(*g*) If contact has been made with suspect individuals,

the head and body should be inspected at frequent intervals.

(*h*) If infestation occurs, vigorous treatment should immediately be adopted.

Obedience to these simple rules will prevent any serious infestation and save considerable trouble and worry.

(2) Cleansing of Infested Persons. If cleansing is carried out in a methodical manner, no difficulty will present itself in the disinfestation of the person. The head and body require somewhat different treatments and, if both are infested, the head should be dealt with first.

In treating the *head*, a mild infestation may be dealt with by means of a fine tooth comb which will remove lice and nits. If the head is badly infested, the hair should be cut as short as possible before treatment commences. A paraffin oil emulsion containing at least 30 per cent. of the oil should be thoroughly rubbed into the scalp, which should then be entirely covered with a towel. This emulsion may be made by incorporating 50 per cent. paraffin with any good soft soap, the mixture being heated and vigorously agitated. The towel should be left in position for at least one hour, and may, if desired, be left overnight to ensure that all the nits as well as the lice have been destroyed. After the towel has been removed, the head should be shampooed and combed thoroughly to remove the dead lice and nits. Five per cent. of oil of sassafras, oil of eucalyptus, or oil of cedarwood may be added to the emulsion, this rendering the mixture more toxic to lice. If desired, an ointment of paraffin, cotton-seed oil, and a small quantity of oil of lemongrass may be used. The hair

should be shampooed with the following mixture, the constituent ingredients having been boiled together :—

½ lb. soap.
1 oz. borax.
1 qt. water.

The lather should be left on the hair and, if used for the destruction of crab or body lice, on the part affected. Further shampooing and combing should be carried out and the head dried.

In delousing the body, mild infestations should be treated by thickly smearing the skin with the undiluted paraffin emulsion mentioned previously. This must be well worked into the hair of the part affected, while, if desired, the mixture of soap, borax and water may be used. This should be followed by a hot bath and the provision of clean clothing. In cases of severe infestation, the body hair should be removed before applying the emulsion. The hair as it is removed should be dropped into a 2 per cent. solution of lysol. Care should always be taken to prevent scattering of the parasites. Thus, when undressing, it is best to stand in the bath to prevent any lice falling on the floor. The clothing should be placed in a smooth enamelled basin until ready for attention.

Paraffin has many qualities which render it suitable for delousing purposes. It spreads over the louse, closes up the spiracles and is definitely toxic where it penetrates. Penetration is assisted by the addition of one of the essential oils already mentioned.

(3) Treatment of Clothing. *Dry heat* at a temperature of 55–60° C. and an exposure of ten minutes will kill all lice and nits in clothing. The degree of heat must, of course, be regulated by the fabrics to be treated,

and, in certain circumstances, higher temperatures may be applied. Heating chambers should be designed in such a way that the hot air circulates freely. Dry heat is the cheapest and simplest method to apply, while in addition it is also the most efficient.

Steam under pressure is an ideal agent for delousing clothing, as it not only kills all stages of lice but also destroys the organisms in the clothing. Steam is best applied at a public disinfecting or cleansing station, where arrangements can be made for the treatment of the person as well as the clothing.

Fumigation by means of hydrogen cyanide, or carbon tetrachloride vapour will also readily kill all nits and lice in clothing. As these gases are dangerous if employed by unskilled persons, expert operators should carry out the work. Heavy naphtha may also be used for this purpose.

Laundering the clothing is also an efficient method of disinfestation. The standard practice, which is not applicable to woollens, when this method is employed is as follows :—

(*a*) Wash for fifteen minutes at 131° F. in heavy suds.
(*b*) Rinse three times, three minutes each at 131° F.
(*c*) Extract.
(*d*) Run in dryer for fifteen minutes at 140° F. until goods are perfectly dry.
(*e*) Iron.

Clothing may be *ironed* with a very hot iron to destroy lice and nits, particular attention being paid to the seams and folds of the clothing.

Dry storage at 73° F. for ten to fourteen days will kill all lice and nits. Such a method is not, however, readily available, and a longer period would be necessary in this country.

CHAPTER V

OTHER INSECT PESTS

The Cockroach. This insect belongs to an order known as *Orthoptera*, which includes crickets, grass-hoppers and locusts in addition to cockroaches. There are several species of cockroach :—

(1) Common Cockroach (*Blatta orientalis*).
(2) German Cockroach (*Blattella germanica*).
(3) American Cockroach (*Periplaneta americana*).
(4) Australian Cockroach (*Periplaneta australiasiæ*).

The common cockroach and the German cockroach are the two species usually found in houses in this country, while the latter two species occasionally occur in warehouses and hot-houses. None of the common varieties are natives of this country. The original home of the common cockroach is unknown, but it was introduced into this country during the sixteenth century, first into the seaport towns as in the case of the bed-bug, whence it spread throughout the country. The German cockroach is known by different names in various parts of the country, such as " shiner " and " steam-fly." Its introduction occurred towards the middle of the nineteenth century, and while it is occasionally to be found in large numbers, it is not quite so widely distributed as the common cockroach. The common cockroach is fairly common on refuse dumps.

(1) COMMON COCKROACH. This is the insect usually known as the " black beetle," although it is not a beetle in the scientific sense of the term. The general colour

By courtesy of Messrs. Newton Chambers Ltd.

FIG. 12. Oriental cockroach (*Blatta orientalis*).

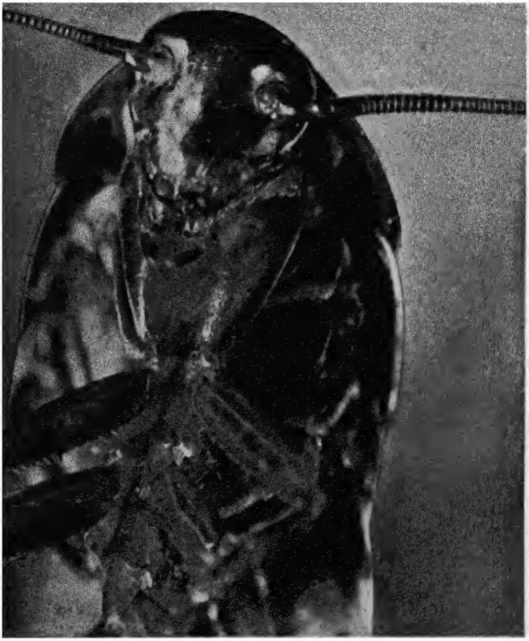
is a very dark brown, but the male and female cockroaches differ in appearance, the wing cases in the male being more fully developed than those of the female. The antennæ are almost as long as the body and are composed of several segments. The wing cases of the

male are dark brown and cover two-thirds of the abdomen, the wings also being brown. The legs are a paler shade of brown and are covered with spines. The male keeps its body clear of the ground when in motion, while the abdomen of the female, which is broader than that of the male, is dragged along as the insect moves. The rear segment of the abdomen is straight in the male, while in the female it is deeply notched. The average length of the insect is some 25 millimetres, but the sexes vary a little in size.

There are approximately three times as many females as males. The pairing of the male and female takes place as soon as the insects reach sexual maturity, and ten days after this occurs, egg-laying commences. The eggs are laid in a capsule containing sixteen eggs, arranged in two rows. This capsule is some ½ inch long and ¼ inch broad. The capsule is formed like a purse, the eggs in the case being difficult to sterilise, hydrogen cyanide being necessary for this purpose. The capsule is carried by the female attached to the abdomen for varying periods up to five days, being plainly visible to the naked eye. It is finally deposited in a warm, sheltered spot near a suitable food supply. The female lays quite a number of capsules, but all the eggs do not mature. The period of incubation is from two to three months at temperatures above 73° F. Lower temperatures prolong the incubation period.

When the nymphs are ready to emerge, the capsule splits into two portions and the young insects shake themselves free from the case. The nymphs moult immediately upon leaving the egg and are semi-transparent and pale amber in colour, with black eyes. Shortly afterwards, pale brown blotches appear on the

back, this colour spreading until it reaches the legs, which are the last to change. Between two and four weeks elapse before the second moult occurs. The third



By courtesy of Messrs. Newton Chambers Ltd.

FIG. 13. Oriental cockroach (*Blatta orientalis*) photographed from the front to show the pronatum protecting the head. Usually known as common cockroach, or "black beetle."

and fourth moults occur in six to eight weeks and the fifth and sixth in three to four months, provided suitable conditions of temperature exist. When conditions are adverse and food is scarce, the moulting period may be

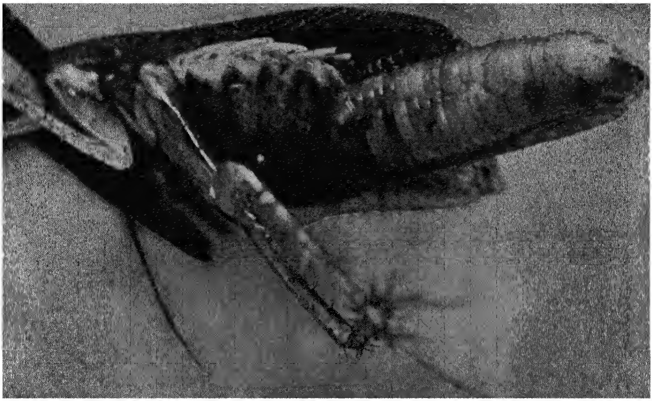
considerably extended. At the sixth moult, the nymph resembles the adult, except that the wings and wing cases are rudimentary. The six moults usually take from nine to twelve months. The nymph eats little and retires to a dark place. Finally the skin splits and, four to six weeks later, the adult insect emerges. The sexes can then be readily discerned. The optimum temperature for development is in the neighbourhood of 73° F., while an abundant food supply and a sufficiency of moisture is also necessary. If higher temperatures with food and moisture are available, maturity will be reached at a much earlier date. As the temperatures of their normal habitat in houses in this country are never regularly so high as the optimum temperature mentioned, development may be retarded. This insect is exceptionally cosmopolitan, being found everywhere on land.

(2) THE GERMAN COCKROACH. This insect is smaller than the common cockroach, being some 14 millimetres long. It is dark yellow or light brown in colour, while the female is broader than the male. Both male and female have fully developed wings. The antennæ appear to be ringed in brown, while on the first body segment there are two long brown streaks. The wing cases are light brown, the wings brownish on the anterior aspect, and the legs pale. The back is usually darker along the centre.

The insects pair on reaching maturity, which is usually a fortnight after the final moult. Eggs are laid about a week later enclosed in capsules, each containing an average of forty eggs. The capsule is approximately $\frac{1}{4}$ inch long by $\frac{1}{8}$ inch broad, and is rectangular in shape, the depressions between the eggs being well marked. It

is dark, glossy brown in colour. The capsule is carried by the female until the young are ready to hatch out. One or sometimes two capsules are deposited by the female before death occurs.

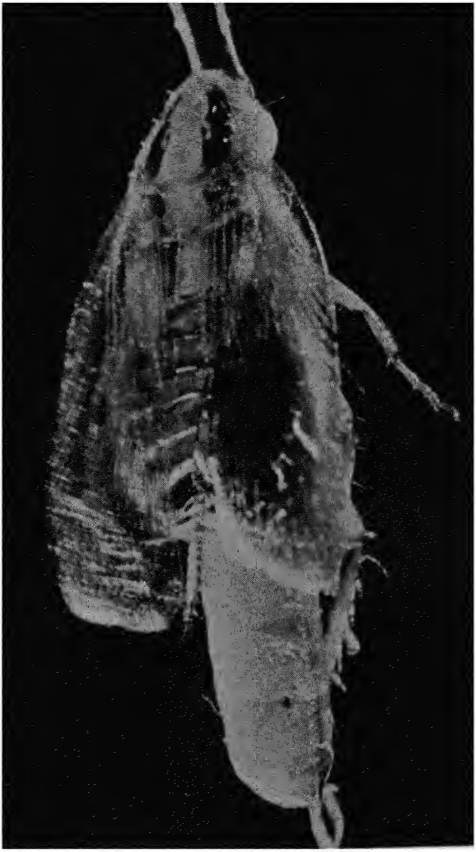
The nymphs are long and white, possessing six legs which are extremely active. The body flattens and broadens



By courtesy of Messrs. Newton Chambers Ltd.

FIG. 14. German cockroach or sheen fly (*Blattella germanica*). Female with egg case projecting from the abdomen.

out, and the colour changes to grey, then to brown and finally to black. The legs and thorax, however, remain pale. This change of colour takes some three hours to complete. The first moult occurs after eight days, and ten days later the second moult takes place. A third moult occurs a fortnight later, with a fourth in a month's time. Finally, the adult stage is reached. The speed with which this is attained varies according to the food supply available and the conditions of temperature and



By courtesy of Messrs. Newton Chambers Ltd.

FIG. 15. Egg case projecting from the end of the abdomen of female steam fly (*Blattella germanica*).

moisture present. This type of insect does, however, complete its development more rapidly than the common

cockroach. Its habitat is bakeries, laundries, hospitals and hotels, while it is also found on shipboard, and in private houses.

(3) THE AMERICAN COCKROACH. This is the largest species found in this country, being some $1\frac{1}{2}$ inches in length. Both sexes have fully developed wings which are larger than the body. It is reddish-brown in colour, the first segment of the thorax being mottled with lighter brown. The antennæ, wings and wing cases are all longer than the body.

The American cockroach is fairly common on shipboard, in warehouses, breweries and sugar refineries, but it has not established itself in dwelling-houses. The number of capsules deposited varies, and although many capsules are laid if the temperature is high, only a small number will be laid at low temperatures. The average number of capsules deposited is fifty. The capsule is carried by the female for periods up to three days, the number of eggs in each capsule varying from fourteen to twenty. The incubation period of the eggs varies from nineteen to seventy days, the insect moulting six or seven times before it reaches maturity. The life cycle varies from eight to nineteen months, while the female lives one to two years. This is also a very cosmopolitan insect.

(4) THE AUSTRALIAN COCKROACH. This resembles the American insect, although it is smaller, being approximately one inch in length. The first segment of the thorax has a bright yellow ring within the margin, and there is also a yellow streak on the sides of the wing cases. The insect is mainly a vegetarian and is found in glasshouses, but not in domestic premises, although it may be found on fermenting manure heaps. The life

roaches die within two to four weeks if they are removed into a dry atmosphere.

Cockroaches are not afraid of human beings, but show a distinct dislike for lighted rooms, having a partiality for darkness. Their mode of progression is by running, their speed and flattened bodies rendering destruction difficult. Their diet is extremely varied—paper, limewash, leather and hair, besides ordinary foodstuffs—but they are very partial to sweetened foods and are attracted by beer. Unlike the bed-bug, they cannot withstand long periods of starvation, death in such cases ensuing in three to six weeks. They do not consume large quantities of food, but taint and spoil foodstuffs with which they come into contact. This is due to secretions from glands of the body and fluid from the mouth.

Dissemination. They are disseminated in various ways. They obtain entrance to warehouses in the various packages received, and should their abodes become over-populated they will migrate to fresh quarters. Infested furniture, groceries and linen are means of introduction into dwelling-houses, while infested hotels and restaurants become distributing centres for the infestation of surrounding property. The cockroach is essentially a scavenger and will consume dead animal matter.

Control. Control measures are many and various, and may be summarised as follows :—

(1) Insect powders.
(2) Sprays.
(3) Traps.
(4) Fumigation.
(5) Heat.

If steps are not immediately taken to destroy these insects, infestation will rapidly increase, while neighbouring premises will also become infested. As a preliminary measure, all cracks and crevices should be sealed to exclude any possibility of entrance. This is particularly important round fireplaces and in cupboards. Skirting boards should fit close to the floor, beading or wood filling being employed to effect this junction where necessary.

(1) INSECT POWDERS. Insecticidal powders form the most common method used for clearing infestations of cockroaches to-day. The effectiveness of such powders depends upon a peculiar characteristic of the insects. When the antennæ touch the powder and become dirty, the cockroach cleans them in its mouth, the poison contained in the powder being thus passed to the stomach. Perseverance is necessary, whatever powder is used. A mixture of 3 parts sodium fluoride and 1 part pyrethrum powder will be found effective. This should be scattered about the haunts of the insects at night, the dead insects being swept up and burnt on the following morning. Care should be taken to ensure that this mixture does not come into contact with any foodstuffs, while children and domestic animals should have no access to it. A mixture of borax and pyrethrum powder or borax and chocolate powder may also be used, while an old remedy consists of a mixture of 2 parts of sugar mixed with 1 part plaster of Paris. A mixture of 10 parts sodium fluoride, 8 parts ground rice and 2 parts calcium phosphate may also be employed. Sodium fluoride or sodium silicofluoride may be spread about or blown into cracks and crevices where the cockcroaches are known to be, with beneficial effect, or, if desired,

a mixture of borax and thick syrup or castor sugar may be deposited on tin plates. It cannot be too strongly emphasised that these materials are poisonous. Where there is no danger to domestic animals or human beings, the following mixture may be used :—

3 cups of linseed meal.
1 cup molasses or treacle.
1 yeast cake softened with water.
2 tablespoonsful of lead arsenate.

This should be spread on pieces of cardboard and placed in the runways of the cockroaches, being renewed daily.

(2) Sprays. Certain types of spray which entice the insects from their hiding places may be used. In many cases the effect of such liquids is to stupefy the insects for a length of time sufficient to allow them to be swept up and destroyed. Half a pound of pyrethrum powder should be soaked in 1 gallon of paraffin for twenty-four hours. The liquid which is decanted may then be used, being vaporised by means of a fine spray.

(3) Traps. While many efficient types of traps are to be found, their efficiency depends upon the bait employed. This should be changed from time to time. Beer and peeled banana pulp have been used with considerable success. The form of trap generally used in the home is a jam-jar containing the bait. A funnel is fixed in the opening of the jar. A runway is attached to the opening of the funnel, up which the cockroaches travel to fall eventually into the liquid in the jar. A stiff paper cone can be used in place of the funnel if desired.

Adhesives such as a mixture of resin and linseed may

also be used, being spread upon pieces of cardboard. Such baits should be frequently renewed.

(4) FUMIGATION. Gaseous fumigants may be used with satisfactory effect. These are :—

(*a*) Sulphur dioxide. Two pounds per 1,000 cubic feet for twelve hours should be used. This gas will bleach and tarnish.
(*b*) Hydrogen cyanide. This is satisfactory, but is rarely used for this purpose on account of its poisonous nature and the need for the presence of skilled operators.

(5) HEAT. While this method cannot generally be applied to dwelling-houses, it may be used in suitable surroundings with satisfactory effect, provided steam is available for heating purposes. A temperature of 130° F. is essential, and if this can be so maintained for a sufficient length of time that penetration into the lairs of the insects will be effected, few will survive.

The Cricket. The house cricket or *Gryllus domesticus* is a widely distributed pest, being a common inhabitant of bakeries, besides being frequently found in dwelling-houses near firegrates and under hearths. Indeed, it makes its habitat in any warm situation. It is also common on refuse tips and in refuse destructors. During the past few years, plagues of crickets have been reported in many parts of the country. Some authorities are of opinion that such plagues may be due to cyclical changes in the life history of the insect, but more research is required on this subject before any definite pronouncement can be made. Domestic infestations have been caused by using clinker from refuse destructors for road-making and for the foundations of garden paths. With the increased installation of central heating

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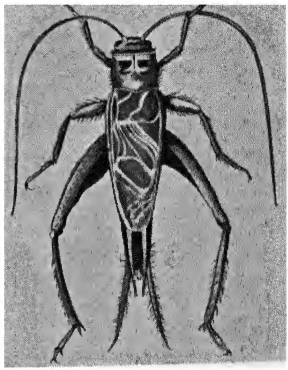
systems during the past few years, crickets have been attracted to domestic premises in large numbers, because of the uniform heat maintained.

The adult insects are grey or greyish-yellow in colour with entirely brown heads and long antennæ. Each insect possesses three dark bands, one between the antennæ, another between the eyes and a third situated at the rear of the head. The eggs are laid singly in cracks and dark crevices, behind wainscotting and on refuse tips. There are eight nymphal stages, so that the life is long, only one brood being hatched each year. In summer, crickets leave houses and live out of doors in rubbish and refuse. They feed on a variety of substances. While they do no natural harm, their presence is distasteful to many people. The peculiarly shrill nose produced by the male insect rubbing its wings together tends to affect the nervous system of persons living in infested premises or near refuse dumps in which crickets have made their homes. The insects are capable of gliding comparatively long distances, particularly with a following wind, while they can move rapidly when disturbed.



By courtesy of Associated Fumigators Ltd.

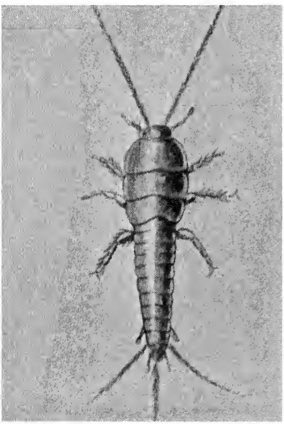
FIG. 16. House cricket.

The pests are troublesome to deal with, but baits similar to those used for cockroaches may be employed with success. Accumulation of refuse adjoining dwelling-

houses which shelter the insects in summer should be removed. For refuse dumps the following bait should be used :—

1 lb. Paris green or white arsenic.
25 lb. bran.
1 lb. salt.
2 galls. molasses.

These ingredients are mixed together into a paste with water, and should be scattered over the dump on a warm evening. Care should be taken that domestic animals do not obtain access to this bait. If controlled tipping of refuse were practised in the manner recommended by the Ministry of Health, tips would not become so readily infested.



By courtesy of Associated Fumigators Ltd.
FIG. 17. Silver-fish.

The Silver-fish. This insect belongs to the order *Thysanura*, and is one of the most primitive of insects, the body being covered with scales. The silver-fish or *Lepisma saccharina* is reasonably common in houses and bakehouses, the insect being attracted by warm surroundings.

The adult silver-fish is a silvery, shiny, elongated creature with long antennæ and three bristle-like appendages at the termination of the abdomen, because of which it is often given the name " bristle-tail." The

body is covered with silvery scales similar to those of a fish. The insect can dart about with great rapidity. The female lays from six to ten eggs at intervals in crevices and cracks. The young, which resemble the adults, emerge in forty-five to sixty days, there being four nymphal stages before the adult stage is reached. The full life cycle takes two years to complete in temperate climates, but in the tropics the insect may become full grown in seven to nine months. Specimens have lived for 300 days without food.

The silver-fish is not fond of damp situations, preferring situations near fireplaces and hot-water pipes, prefers starchy food, and may be very destructive to books and papers although it seldom does much damage, acting chiefly as a scavenger. When hungry and when suitable food is scarce, the insects will attack a variety of substances and may even devour one another.

Methods of control vary according to circumstances. The following comprise the most common methods in use:

(1) Pyrethrum or derris powder may be sprinkled round the haunts of the insect.

(2) A mixture of starch paste, glue and boiled linseed oil brushed on narrow strips of paper may be laid around the haunts to form an effective trap.

(3) Insect powders may be dusted in all likely places. A useful powder is made up of 45 parts sodium fluoride, 15 parts sugar, 15 parts flour, 10 parts borax and 15 parts pyrethrum powder.

(4) Liquid insecticides may be used with varying success.

(5) Books should be placed in a trunk and treated with a mixture of 1 lb. paradichlorbenzene.

(6) Traps baited with arsenic or sodium fluoride may be

used, but it should be remembered these are very poisonous. The formula for such baits is—

(*a*) $\frac{3}{4}$ oz. white arsenic.
1 lb. wheat flour.
Water is added to form a paste.

(*b*) 1 lb. sodium fluoride.
8 lb. wheat flour.

This mixture is applied as a powder, being blown into cracks and crevices where the insects are to be found.

(7) Fumigation with sulphur is useful, if circumstances allow.

The firebrat or *Thermobia domestica* is closely allied to the silver-fish. It can withstand higher temperatures, being often found near ovens where the brickwork is unsound, behind fireplaces and in kitchens, bakehouses and boiler rooms. It is similar in shape to the silver-fish, but can be distinguished by its dark mottled appearance. Its life history is less known, but it is probably analogous to that of the silver-fish. The insect is most active at temperatures of 90° to 100° F. While its food is very similar to that of its ally, it is also fond of sugar and sweetstuffs. Control measures are similar to those required for silver-fish.

The Ant. While there are some 3,500 species of ants, any one of which may become a household pest, the only species which habitually make their homes in houses are the red house ant (*Monomorium pharaonis syn Myrmica molesta*), and the Argentine variety. Once such insects become established, they are difficult to eradicate, and, when once seen, no delay in adopting measures of control should be allowed to ensure. Ants belong to the order *Hymenoptera*, undergoing complete metamorphosis, and are included in the super

family *Formicoidea*. The red house ant is a frequent inhabitant of bakeries, but is also often to be found in private houses, particularly those which possess central heating systems, the insect being usually attracted by heat.

LIFE HISTORY. This is somewhat complex, and there are three types of adults—males, females and workers. Each may be recognised by the abdominal constriction known as the *petiole*, which varies in all three cases. The adult worker, which is the smallest of the three types, is approximately $\frac{1}{12}$ inch long. The nest, which is often large, is located in the foundations of houses, in walls, under floors, or behind the brickwork of ovens and boilers. Breeding takes place irrespective of season, and while the nests are usually difficult to find, they may sometimes be traced by following the tracks of the insects. The nests may, however, be many yards away from the opening where the ants appear.

The insects commence their *life cycle* on the wedding flight. The females, after being fertilised, shed their wings or have them bitten off, thereafter crawling into cracks or crevices to form the nest. The female then becomes a queen and lays several eggs which are hatched in the nest. The larvæ which emerge are legless and are cared for by the worker ants, a sexless form of females. It should be noted here that the male ant, whose purpose in life is to perpetuate the species, possesses wings throughout life. The larvæ are fed by the queens with a secretion from the body, which is probably saliva. When fully grown, the larvæ pupate and eventually emerge as full-grown ants. If the nest is disturbed, the workers may be seen hurriedly engaged in carrying away the pupæ, and not the eggs as is often

thought. The insects which are usually seen travelling about are almost always worker ants, the males and females remaining in the nest. The females lay eggs continuously, and both they and the males are fed by the workers.

CONTROL. The measures used in the control of these pests are numerous, but it must always be remembered that it is necessary to kill the queens or a large proportion of the young if success is to be attained. The direct killing of the workers by means of poisoned baits is practically useless, although such action may reduce the quantity of food reaching the nest, provided the policy is vigorously pursued. Insect powders of the pyrethrum type are useful, while the ants can also be trapped by means of sponges soaked in sugar syrup to which a suitable poison has been added. If the nest can be located, it may be treated with a good liquid insecticide—for example, petrol, boiling water, or kerosene solution, obtained by mixing one pint of kerosene in one gallon of water. Another effective insecticide is procured by mixing one pound of powdered naphthalene in one gallon of paraffin. Heavy naphtha may also be used. As this is heavier than air, an aperture should be made down to the nest when located, and the chemical poured into this aperture. The aperture should afterwards be sealed, when the heavy vapour will penetrate the entire nest and kill the colony. Repellents are sometimes used. Paraffin is very useful for this purpose, and any woodwork across which ants are known to pass should be painted with this material. The drawback to paraffin is its strong smell, which is liable to taint foodstuffs if stored near-by. A useful killing powder is made up as follows :—

20 parts icing sugar.
40 parts calcium phosphate.
40 parts sodium fluoride.

This powder should be blown into the haunts of the insects by means of a bellows or a powder spray. Another suitable poison for use in sprinking runs is composed of—

6 parts by bulk sodium fluoride.
2 ,, ,, ,, corn starch.
2 ,, ,, ,, pyrethrum.

This powder is also useful in dealing with infestations of cockroaches, crickets, silver-fish and earwigs.

To ensure that the poison reaches the nest and kills off the entire inhabitants including the workers, the following mixture is recommended :—

1 pint of water.
1 lb. sugar.
3 oz. honey.
27 grains thallium sulphate.

These ingredients are mixed together and heated almost to boiling point. A round pill-box is soaked in wax, while the bait is poured over blotting-paper, pieces of which are placed in the box. The sides of the box should be perforated to allow the ants to enter. The worker ants feed on this mixture, and as the action of the poison is slow, they survive for a sufficiently long period to carry the food back to the nest, where it is regurgitated. The young feed on this regurgitated material and are eventually poisoned.

The common garden ant sometimes invades houses in search of food. The nests are usually made outside the premises, and similar measures of control to those already mentioned are required.

The Itch Mite. Mites are not insects but occur in the Class *Arachnida*, which class also includes spiders, ticks and scorpions. The itch mite belongs to the family *Sarcoptidæ*. The itch mite or *Sarcoptes scabei* is responsible for the exceedingly uncomfortable skin irritation known as itch or scabies. The female, which can just be seen with the naked eye, is larger than the male. The dorsal surface is marked by numerous parallel lines, with the exception of a median area which bears scales and short spines. A number of long and short hairs are also present. It is provided with four pairs of legs, the foremost two pairs being widely separated from the hindmost pairs. The legs are very short. Some possess suckers while others exhibit long bristles. At the base of the head there are two bristles.

The mite excavates burrows in the skin, usually in the folds—*i.e.*, between fingers and toes, at the wrist, elbows, waist, skin of scrotum and knee. In women, the folds of skin under the breasts are also affected, whilst almost any part of a child's skin may be attacked. The burrows are usually made while the host is at rest. Egg-laying commences simultaneously with burrowing, continuing from four to five weeks, one or two eggs being deposited daily. The female usually deposits between forty and fifty eggs. The eggs hatch in from three to four days, and the larvæ bore directly from the parent burrow or pass to the surface of the skin, entering the hair follicles to form vesicles. The larval stage occupies two to three days, moulting taking place in the burrow. There are two nymphal stages, the nymphs making shallow, narrow burrows. Both the male second nymph and the pubescent female become adults following the second nymphal stage. The

life cycle from egg to adult lasts about a fortnight, while the adult mites live from three to five weeks.

Itch mites secrete an acrid fluid, their presence in the skin causing intense local irritation, resulting in prolonged scratching which may produce more serious effects than those caused by the mite itself. Where burrowing has occurred, small vesicles are formed. These are ruptured by scratching, minute crusts being formed on healing. The mites are usually found near the vesicles, but not within them.

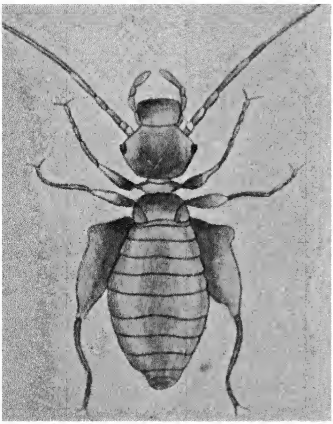
It is essential that the mite should be detected before any final diagnosis of scabies is made. The mite can be easily seen on a white skin in a good light by the aid of a lens. Scabies can be distinguished from pediculosis by the absence of the red halo.

Mites are not usually transferred by transient contact with infested persons, although instances of such transmission have been recorded. They are commonly transmitted by close contact with infested persons or by using infested clothing or bedding. Cast-off clothing from affected persons may remain affected for at least eleven days.

The clothing of the affected persons should be disinfested by steam or sterilised in an electrical disinfestor. The patient is best treated by a Danish method, which liberates sulphuretted hydrogen. This is obtainable in the form of an ointment known as *Kathiolan*. The patient is bathed and dried, the ointment being thoroughly rubbed into the skin of the parts affected. The ointment is allowed to soak into the skin for twenty minutes, when the patient is put to bed until the following day. A further bath is then given and fresh

underclothing provided. A single application of this ointment is usually sufficient.

Psocids. Psocids, or book lice as they are often termed, belong to the order *Anoplura*. Very little is known of these insects, but the most likely ones to become pests are *Liposcelis divinatorius*. This breeds in grain stores and may invade houses, besides which they are often present in new houses. The insects do very little damage, but householders usually object to their presence. One species makes a continuous ticking noise similar to that of the death watch beetle, but does not damage timber.



By courtesy of Associated Fumigators Ltd.

FIG. 18. Book louse.

The adult is a minute grey, whitish or brown insect with long antennæ. Wings may also be present. The eggs are deposited in the cracks of floors and woodwork and, as might be thought, between the pages of books in libraries, and are laid during the entire year, while the insects live together in colonies. The life cycle is approximately twenty-one days in summer and one hundred and forty days in winter.

As these insects are associated with damp conditions, the drying and airing of premises will eventually terminate any infestation. Woodwork may be treated with

creosote, while dry heat for two to three hours at a temperature of 120°–140° F. will destroy all insects. Sulphur may be used for fumigation purposes in the proportion of 25–30 oz. per 1,000 cubic feet. Where this insect has attacked valuable collections of manuscripts in libraries, and also museum specimens, ETOX will be found to be an ideal fumigant to use against this pest.

The Earwig. Earwigs belong to the order *Dermaptera* and are a major pest in gardens, sometimes also invading domestic premises in large numbers. The commonest species in this country is *Forficula auricularia.* All earwigs possess wings, the forward pair being small and square, and the rear pair, when present, being shaped like the human ear. They feed at night, seeking shelter during the day, and never breed indoors.

With regard to methods of control, repellents such as paraffin, alum solution, or a solution of carbolic acid may be painted round window and door frames. Upstairs windows should not be forgotten, while any surrounding creepers should be cut away. Boiling water will kill the insects immediately, while borax scattered about is said to prevent their entrance into houses. They may also be trapped by means of sacking bands or by inverted flower pots stuffed with straw. A good trapping bait is made up as follows :—

7 lb. bran.
¼ lb. Paris green.
3 lb. meat meal.
3 lb. sugar.

This is scattered about known haunts in the ratio of 1 lb. per 100 square yards. In using such bait, care must be taken to ensure that no harm can come to domestic

animals or birds. The following bait may also be used in a similar fashion :—

1 lb. bran.
2 oz. sodium fluoride.
1 pint water.
4 oz. black treacle.

Wood Lice. Wood lice belong to the order *Isopoda* and are members of the same class, *Crustacea*, which also includes lobsters and barnacles. They enter houses, being attracted by dampness, and are thus almost invariably found in damp situations. They do no damage, but are merely a nuisance.

To prevent infestation, the causes of dampness should be removed from the immediate vicinity of any house, together with heaps of stones such as rockeries and garden refuse. A suitable poison bait is made up as follows :—

1 lb. coarse oatmeal.
1 oz. white flour.
1 oz. Paris green.

This should be thoroughly mixed and placed in a wide-mouthed bottle, from which it should be sprinkled near the haunts of the insects through a perforated cork or lid. This mixture is exceedingly poisonous and should not be touched with the hands, while care should be taken to ensure that no harm comes to domestic animals or birds.

The House Fly. This is the commonest insect found in dwelling-houses throughout the country, and belongs to the order *Diptera.* The house fly, *Musca domestica*, in its adult stage is one of the most troublesome and dangerous insects. Its general colour is a mouse grey,

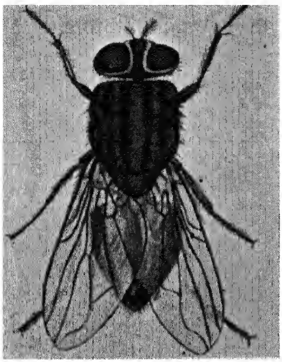
the thorax being marked with four broad, dark, longitudinal stripes. The sides of the basal half of the abdomen are yellowish in colour and are somewhat transparent, the posterior segment being brownish-black with a dark longitudinal line extending along the middle of the back. The legs are blackish-brown, while the wings are clear except for a yellowish tinge at the base.

Life History. The house fly undergoes complete metamorphosis. Mating occurs at any time from two to twelve days after the adult stage has been reached. The eggs are deposited singly, from 100 to 150 being laid at one time. A female lays several batches of eggs, some 600 to 900 in number, during her lifetime. The eggs are deposited in manure heaps, decaying animal and vegetable wastes, kitchen refuse and refuse dumps; that is, on practically any animal or plant wastes in which decay or fermentation is taking place. The egg is white, oval in shape, and is approximately 1 millimetre long. They are visible to the naked eye. The eggs hatch in from eight to twenty-four hours at temperatures of from 68° to 80° F. Hatching may be delayed by lower temperatures.

The larvæ develop rapidly when warmth and food are available. There are three larval stages, the last one being reached in four to eight days. The mature larva is white in colour and conically cylindrical in shape. The body tapers from the centre towards the posterior extremity, is legless and is composed of twelve segments. When the larva matures, it ceases feeding, the skin begins to contract, and in a few hours a puparium is formed. Within this the pupa develops. The pupal period occupies four to five days, although it may be shortened by high temperatures or prolonged by cool

weather. When this stage is complete, the adult fly emerges. The life cycle is varied by temperature, food and other factors, but usually occupies from eight to twenty days.

HABITS. In cooler climates, the fly does not breed continuously, but it is thought to hibernate during winter. Some observers maintain this view, while others state that hibernation in the form of larval or more likely in pupal stages takes place. The favourite breeding places of the house flies are manure heaps which contain horse manure mixed with straw. Human excrement in open privies and in back alleys and yards is also much favoured, while other breeding grounds are where fermentation occurs, decayed vegetables, and uncontrolled refuse tips. The house fly will breed in practically all decaying and fermenting animal and plant wastes, and, when the quantities of such materials found present in and around our large towns is considered, it is scarcely surprising that this pest occurs in countless numbers.



By courtesy of Associated Fumigators Ltd.

FIG. 19. Common house fly.

Flies occur in large numbers in dwelling-houses during the autumn, when they migrate indoors to find warmth, shelter and food. They are constantly on the move, exploring every surface in their search for food and leaving excreta on innumerable objects. The house fly

feeds principally on liquids such as syrups, milk sugars, moisture on decayed fruit and vegetables, sputum, fæcal wastes and water. It also seeks food on moistened human surfaces such as the mouth, nostrils, eyes, sores and wounds, and on meat, cheese and other foodstuffs. If left undisturbed, the fly can engorge in less than thirty seconds. It dissolves dry substances by means of secretions from its salivary glands and by regurgitating part of the liquid present in its crop. This habit is employed on every surface which the fly tests with its proboscis, the spots produced being commonly known as "vomit spots." Regurgitation undoubtedly assists in the spread of pathogenic as well as non-pathogenic organisms, as the fly may and often does pass from infected matter to foodstuffs. Thus, infection may be transmitted either by regurgitation, by fæcal waste or even by the insects' feet. In addition to its filthy feeding habits, a fly is, by reason of its hirsute body and legs, an ideal disseminator of organisms picked up in the filthy wastes through which it has roamed. Its feet are provided with two flattened pads thickly covered with hairs, from which a sticky substance is exuded. This material enables the fly to walk on glass or on ceilings and to gather or leave behind any filth attached thereto. The insect is a vigorous flyer and can cover long distances although it much prefers to be transported. Six hundred yards is about the average flight. Its life span is at least one month in summer and longer during cooler months, if food and shelter are provided.

FLIES AND DISEASE. The disease-producing capabilities of the house fly cannot lightly be dismissed. Indeed, this problem is one which demands the careful attention of all Public Health administrators. The house fly may

affect the health of man in any one of the following ways :—

(1) By annoying and irritating persons to such an extent that their vitality is reduced. This is true especially in the case of children, old persons, invalids, or persons suffering from nervous disorders.

(2) By acting as ideal mechanical distributors of filth containing bacteria, protozoan cysts, helminth eggs, etc., which may be directly transmitted to man's food and person.

(3) By taking into its intestinal tract all kinds of bacteria, etc., which may afterwards be distributed by regurgitation or in fæcal matter.

(4) By serving as an intermediate host in the life cycle of certain parasitic worms.

The following pathogenic bacteria have been isolated from the house fly :—

(*a*) Typhoid and paratyphoid fevers.
(*b*) Dysentery.
(*c*) Tuberculosis.
(*d*) Plague and anthrax.
(*e*) Contagious abortion.
(*f*) Infantile diarrhœa.
(*g*) Eye and skin diseases.

Cases are recorded of disease outbreaks due to the above organisms having been spread by flies. In addition, yaws or tropical ulcer and conjunctivitis have been caused by flies, while the insects have been reported as spreading plague, smallpox and leprosy.

Of the innumerable varieties of flies which frequent dwelling-houses only the house fly can act as a mechanical carrier of disease.

Control. As flies are a constant menace to the health and happiness of countless individuals, control measures should be speedy and sure. Efforts to control these insects must be directed towards —

(1) The breeding places.

(2) Destruction of adults by poisons, sprays and traps.

(3) Screening of foodstuffs.

(1) *The Breeding Places.* The frequent removal of accumulations of manure and house refuse should obviously be the main line of attack. The common practice of the weekly removal of house refuse and the supply of premises with covered receptacles to contain such refuse is usually sufficient always providing such receptacles are provided with a tight-fitting lid. Defects in the system are usually due to the intervention of holiday periods and sickness. In addition, large numbers of ashpits, which form ideal breeding grounds for flies, are still present in many districts. The abolition of these anachronisms is considerably overdue. This also applies to uncontrolled rubbish dumps and refuse tips, still too frequently seen throughout the countryside. Dustbins, after emptying, should be rinsed out by their owners with a small quantity of lysol. Then, as the refuse is periodically inserted, a little borax should be sprinkled over the material.

The storage of horse manure is the most potent factor in the dissemination of flies generally, and unfortunately the standard of cleanliness of stables, even in our large cities, leaves much to be desired. Even when manure is removed strictly in accordance with existing byelaws, the nuisance from flies is not always abated. The larvæ

migrate into cracks and crevices in and adjoining the manure pit, such apertures providing ideal opportunities for future development. Scrupulous cleanliness of paving and surfaces surrounding manure pits is essential. Legislation should provide for supplying and maintaining manure receptacles with fly-tight covers, and also for regulating the removal and conveyance of manure on the highway. In addition, manure should not be dumped near any dwelling-houses or shops. Manure should be removed at least twice weekly during April to September, and weekly during the remainder of the year. After dumping, it should be immediately spread or dug in, or covered with earth. Closely packed manure when covered with earth to a depth of 12 to 18 inches generates such heat that any living insect quickly perishes.

Byelaws regulating the storage and removal of offal and bones should be rigidly enforced, in order to eliminate the chief source of danger from blowflies.

(2) *Destruction by Poisons, Sprays and Traps.* The spraying of manure may be practised as an alternative control measure. Half a pound of hellebore mixed with 10 gallons of water should be thoroughly stirred and allowed to stand for twenty-four hours. This quantity of liquid is sufficient to treat 10 cubic feet or 8 bushels of manure, and should-be sprayed with a hand pump. Powdered borax, in the proportion of 1 lb. to 16 cubic feet of manure, will also be found effective. The powder should be evenly distributed and well watered in. If applied in these proportions, the fertilising value will not be affected.

The spraying of manure with one of the many solutions now upon the market is productive of excellent results.

Paraffin may be used where expense has to be considered, while treatment with coal-tar oil is also to be recommended. This is sprayed over the heap every day, after manure has been added, some 100 cubic centimetres being used on each occasion. Fly-papers are a popular means of destroying flies, but have the obvious disadvantage of killing adults only, the larvæ and eggs not being affected. Jam jars, the outsides of which have been painted with a sticky mixture composed of 8 parts powdered resin and 5 parts castor oil heated together, are equally effective.

A mixture of formalin and lime water placed in a tumbler and set over a saucer lined with blotting-paper also supplies an effective poison. Many types of traps are in use, the commonest being constructed of wire gauze, fashioned like a balloon. They are very effective, the traps being placed in boiling water in order to kill the flies.

Other effective poisons for flies are sodium arsenate, pyrethrum or powdered derris root. It will be unnecessary to stress the fact that arsenical and cyanide preparations should *not* be used indiscriminately for domestic use. A spraying solution of sodium arsenate is made up as follows :—

1 lb. sodium arsenate.
10 lb. crude sugar or treacle.
10 galls. water.

This liquid, valuable in the case of manure heaps, should be sprayed over the surface of the manure. Pyrethrum or derris powder sprinkled over manure heaps is also very effective.

(3) *Screening of Foodstuffs.* Fly-proof covers for food

and food stores are essential. The simpler these are, the more satisfactory will the results be, and for that reason only such apparatus should be used. All food should be stored, whenever possible, in refrigerators or fly-proof safes, and all open windows in rooms in which food is stored should be fitted with gauze fly screens or shutters. No food likely to attract flies should ever be left exposed. It is also of the utmost importance that all articles and material associated with the transmission of disease, including fæces and sputum, should be properly protected with a view to preventing flies gaining entrance thereto during their search for food.

PART II

PRINCIPLES AND PRACTICE OF DISINFESTATION

CHAPTER VI

BUILDING CONSTRUCTION AND INFESTATIONS

In many instances lax methods used in the construction of buildings in the past have encouraged the infestation by providing ready-made harbourages for insect pests. Before considering methods of fumigation and the use of other control measures, it is necessary to understand where such harbourages may be found and the types of construction or misconstruction which have given rise to them.

Faults in Construction. When houses are built, the foundations are first completed, after which it is usual to erect either a 9-inch solid wall or an 11-inch cavity wall extending upwards. In laying bricks or in fitting stones in the case of stone-built houses, the bricklayer or mason spreads the mortar with a trowel. The joints, particularly those on the outside, are then made good. There are, however, many cavities left on the internal walls, due to inefficient jointing, although such joints are, in many cases, left to form a key for plaster. This rough jointing is particularly noticeable in the roof space, where the brickwork is bare of plaster, and also under floors, round hearths and in flues.

Air bricks are usually inserted at the base of all walls underneath a suitable dampcourse, while beneath the floors the sleeper walls are built with brickwork arranged on the "hit-and-miss" principle, to assist sub-floor ventila-

tion. The brickwork in this space which exists between the floor of the lowest room and the concrete foundations abounds in cracks and crevices, which form ideal harbourages for a variety of insect pests. This is brought about because, in such situations, it is seldom considered necessary to finish off the joints. It should also be noted here that such badly jointed brickwork in roof spaces and under floors may assist in the dissemination of vermin from one house to another, and also in the diffusion of gaseous fumigants to adjoining property.

It is usual to carry water and gas pipes through the brickwork underneath the dampcourse, both pipes being generally laid in one trench. In the majority of instances the soil is replaced loosely in the trench, while the holes in the brickwork are rarely made good. Vermin may move by means of such apertures *viâ* the loose sôil in the trench to similar trenches or openings in adjoining houses, while poison gases used in their destruction may be diffused in a similar manner.

Window and door sills are generally bedded at both ends in cement or mortar. In many cases leakage is possible owing to shrinkage between the wood and the jointing material. In old houses the brickwork behind the firegrate will often be found to be only 4½ inches in thickness. In addition, such brickwork rarely possesses properly constructed joints, while, even if the joints are satisfactory, cracks often appear, as may be instanced by the number of complaints received of smoke percolating from one house through to the neighbouring property. The chimney-breast and adjoining brickwork may not have been carefully built.

In cavity walls the sub-floor ventilators often communicate with the cavity, which may pass completely

round an entire block of houses, since party walls are not always carried through and bonded into the external brickwork. In addition, the cavity is invariably carried to the highest point adjoining the eaves, but the top of such cavity is not always sealed. This point should never be overlooked in fumigation work. Architects state that these openings under roof coverings are left purposely to provide ventilation in the cavity. It would be possible, however, to provide such ventilation by the insertion of air bricks at a slightly lower level than the upper level of the wall, and by the sealing of all openings along the upper portion of the cavity. Ventilation would still be efficient, and would, indeed, be more effective, while ventilators placed in this manner could be properly sealed from the outside. It is obvious that if cavity walls are left open at the top the only manner in which such apertures may be effectively sealed when fumigation becomes necessary will be to strip the roof covering for a distance of 2 feet from the double eaves course and seal externally. This, of course, will render fumigation a costly proceeding.

It is usual to provide wall vents in bathrooms, water-closets and kitchens. Such vents, when built into cavity walls, are not always properly sealed from the cavity, as there is no plaster on the lower side. The two vents in adjoining houses may be placed in very close proximity. In some instances they may be only 15 inches apart. Vermin may enter the ventilator and so obtain entrance to the cavity. From there they will travel to adjoining houses, entering by a similar ventilator, and in time they will infest the entire block of houses. Similarly, when fumigation is in progress, the gases used may travel to adjoining houses, not only endangering life, but reducing

the concentration of the gas and so lowering its efficiency. It might be maintained that the ventilators could, if suspected, be sealed on the inside of the room. If this were done, however, any vermin present in the cavity or in the ventilator during fumigation operations would remain unharmed. It is advisable to inspect all ventilators and seal any constructed in this manner on the outside.

The unplastered portion of the walls under the floors and in the roof spaces has already been mentioned. Equally important is that portion of the wall which lies between the floor of one room and the ceiling of its lower neighbour. Here, again, brickwork with rough, open joints may be found. Windows built into cavity walls often communicate directly with the cavity at some point in their structure, and this point must not be overlooked.

When houses are provided with solid concrete walls, such walls are usually constructed *in situ* by the use of shuttering. The usual practice is to construct the walls in sections, and where one section has been completed and another constructed upon it, cracks often appear between the two separate sections. In dealing with houses constructed in this manner, careful search should be made for such small cracks.

Floors cover the greatest dead spaces to be found in houses. Floors constructed of butt-jointed boards, with ceilings below, are not of serious importance, as the space which usually exists between each board is sufficient to allow gases to enter and deal with infestation sites found under the boards. Tongued and grooved flooring presents a more difficult problem. Some time after the floorboards have been laid, the boards usually

spring to a greater or lesser degree, leaving small crevices between the tops of the floor joists and the undersides of the boards. Such crevices form ideal breeding grounds for vermin. In the construction of some floors, particularly where the joists are left open to the room below which has no plastered ceiling, plaster board is laid on the joists. This is covered with tongued and grooved boarding to form the floor of the room above. The plaster board often sags slightly between the joists, the cavities which are formed providing suitable harbourages for vermin. In considering the construction of floors, it must also be remembered that there are many dead spaces round hearths which could be profitably filled in.

Ceilings of plaster board or three-ply wood with tongued and grooved boards forming the floor above also assist in the harbourage of vermin. In bedrooms with such ceilings the joints in the sheets are usually covered with wood fillets. The spaces between such fillets and the material used for the construction of the ceiling provides an ideal hiding place for vermin. The fumigation of rooms with this type of ceiling is rendered very difficult, as, if such fillets are removed, there is then a direct opening from the room into the roof space. An important point to note in dealing with roof spaces is the party wall between two houses. In many instances this is not carried up to the roof covering, an aperture being left through which any gaseous fumigant will quickly diffuse.

The construction of food stores, pantries, and coal stores frequently leaves much to be desired. The prevalent use of breeze blocks for partition walls is to be deplored from the point of view of verminous

infestations. If the plaster on such walls becomes defective, the breeze blocks provide ideal harbourages in the numerous crevices which they contain. It is a common practice in modern flats to sound-proof all floors by the use of various materials which can not only harbour vermin but also render their destruction difficult.

Great difficulty is experienced in dealing with hollow partition walls of the lath-and-plaster type such as are so often found in old property. In the case of such walls, it is frequently found that the vertical fir struts are spiked to the ceiling joists and are not properly framed with a head. Vermin enter these partition walls either through defective woodwork, plasterwork, or other open joints. Owing to the fact that the struts are not fitted with a head, it becomes a difficult proposition to fumigate effectively such hollow spaces because of the great leakage which occurs and the consequent loss of concentrated gas.

In the case of semi-detached and terrace houses, another difficulty arises. Party walls are erected with floor joists built into the brickwork. The brick filling between the joints is frequently not properly bedded in mortar, thus leaving the joints open. In many cases whole bricks are omitted. When fumigation is carried out the gas often penetrates from one house to another. When a gas toxic to human beings is employed, a fault in construction will render the vacation of entire blocks of houses necessary. In addition, such faulty work is responsible for the spread of infestation from one house to another.

Elimination of Harbourages. Vermin prefer warm, undisturbed cracks and crevices in which to live and

breed, whenever such can be obtained. It is therefore necessary to avoid, so far as is possible, the provision of comfort, much less luxury, for such troublesome creatures. Harbourages for vermin require consideration from two aspects :—

(1) Those found in existing houses.
(2) Those found in new premises.

While attention must be paid to the elimination of faulty construction in existing property, the sanitary construction of new houses should never be overlooked. Indeed, this latter is equally as important as the consideration of existing property.

(1) EXISTING PREMISES. Considerable time and money may be expended in eliminating likely harbourages for vermin in existing property. One obvious essential is the elimination of all cracks and crevices. These should be carefully filled in with Keen's cement. When a house is badly infested, the picture-rails should be removed before any treatment is commenced, and should not be replaced. Skirtings, window-boards and architraves should be treated in a similar manner. Wooden skirtings should be replaced with the cement type, while the wall plaster should be finished off flush with the door and window frames. Cupboards should be stripped out and replaced after fumigation with the movable type. It is also advisable to discourage the hanging of pictures, especially in houses occupied by certain classes of tenant. Ventilators should receive careful attention, and any surrounding or internal apertures should be filled with cement. All *débris* under floors and in roof spaces should be cleared. Lath-and-plaster partitions should be cleared of all plaster and

have the laths removed, the uprights being covered with good quality wallboard. The joints should preferably be covered with easily removable wood fillets. Paper should not be allowed on the walls in any circumstances, distemper being much more suitable for decorative purposes. Brickwork in roof spaces and under floors should be carefully inspected and all crevices filled in. Attention should also be paid to brickwork round hearths in each room, and to brickwork in the lower portion of the flues. Cavity walls should be sealed where they join the roof, additional air bricks being provided close to roof level as required. Careful inspection will reveal many possible hiding places, which can readily be sealed. In old property, it is doubtful if the expense involved in eliminating harbourages will be justified. It is probably better to rely on a thorough fumigation.

(2) NEW PREMISES. The construction of new houses and flats, particularly those premises intended to rehouse tenants from slum clearance schemes, has received increased attention during the past few years, the plain design of the various fitments being a specially pleasing feature of the more modern tendency. Some attempts have been made to design and construct houses which would be vermin-proof, but these attempts have not, as yet, achieved marked success.

Structural cracks caused by settlement or shrinkage of materials afford ideal hiding places for vermin. It is essential, therefore, that partition materials should be of high quality, free from any tendency to shrink, and that all possible steps should be taken to prevent settlement of the partitions as units. The crack which appears at ceiling level as the result of such settlement affords

excellent harbourage for vermin. Good plaster is essential. Much of the cracking could be avoided if the present practice of carrying first-floor partitions, composed of breeze blocks on wooden joists, was discontinued. Such partitions should be constructed of hollow fireclay blocks or, if preferred, bricks laid on edge. This would also minimise the cracks due to shrinkage in the blocks themselves. It has been suggested that a non-cracking plaster might be used, but there does not appear to be any plaster which will not crack following movement in the material to which it is attached. When wallboards are used, they should be flush-jointed, while the wooden fillets used to cover the joints should be easily detachable.

While there is no evidence to show that wallboards encourage vermin, they should be so fixed that cavities are not formed behind them, the open joints being effectively closed or protected. If used in reinforced concrete structures for ceilings or wall facings, wallboards should be placed in the shuttering before the concrete is poured in. The concrete adheres firmly to the board, thus overcoming any movement due to changes in the moisture content.

The construction of floors presents a more difficult problem. The only types of flooring which can be regarded as completely vermin-proof is a solid structure composed of asphalte, tiles or granolithic laid on concrete. While this method of construction seems to be appropriate, it is unfortunately not always feasible. Tongued and grooved floorboards, if closely clamped, assist in the exclusion of vermin from the interiors of wood-joisted floors. If this type of flooring is badly laid, or if the tongues are broken, tongued and grooved

boards give access to hiding places which may be found difficult to clear. Square-edged boarding is not to be recommended, but it possesses one advantage. When such floors open out after construction, gaps are left between the boards, these gaps being quickly and easily cleared out with a knife. It is also of importance to note that such openings readily allow a fumigant to penetrate into the underlying space. There is no doubt, however, that all wooden floors, whether laid on joists or direct on to concrete, provide more harbourages for vermin than do their solid counterparts. If the floor is carried vertically up the wall to form a skirting in the case of solid floors, no joints will exist between the plaster and the skirting and the skirting and the floor. The sharp internal angle should be rounded off in a similar manner to that found in hospitals, where cleanliness is a fundamental essential. Similarly, the angles between walls and ceilings should be rounded.

As already indicated, wooden architraves, skirtings, picture-rails, and window-boards shrink, the crevices left affording excellent harbourage for vermin. It is therefore very desirable to eliminate, as much woodwork as possible. Mouldings to skirtings and architraves have already been practically eliminated, as have also mouldings to picture-rails. These are now generally manufactured with chamfered edges only, such edges being easily cleansed, and minimising the collection of dirt. Having gone so far, it would be of considerable advantage if all joints between woodwork and plaster-work could be abolished in their entirety. As a precautionary measure, such joints can be sealed with adhesive tape, which is afterwards painted. Picture-rails of stamped steel may now be obtained which can be fixed in position

in the brickwork, the plaster being finished off flush. No shrinkage can then take place, and consequently no vermin will find harbourage. If this material could be adapted for general use as architraves and skirtings, it would be of considerable advantage. In some housing schemes picture-rails are provided in the living-rooms of the houses only. Tiles or cement rendering may be used for skirtings or window-boards. In such cases a 1-inch cover mould nailed to the floorboards at the junction of the skirting and the floor is necessary. This moulding can be easily removed and refixed. Door and window frames may be so fixed as to be flush with the plaster, although it should be mentioned here that the æsthetic effect is not very satisfactory.

Windows of the double-hung sash type provide greater harbourage for vermin than do wooden or metal casements, the latter being the most satisfactory type. All planted-on mouldings of windows or doors are undesirable, since they exhibit a tendency to recede slightly from the joinery to which they are fixed. Built-in furniture such as cupboards, dressers, shelving, hat and coat rails and mantelpieces all provide a highly favourable series of hiding places. Cupboards and dressers should be movable, so that the spaces behind them may be readily cleansed. The posterior edges of shelving should be clear of the wall surfaces by at least ½ inch, while wooden mantels to fireplaces are undesirable.

In fixing permanent fittings such as cookers, baths, sinks, and particularly the pipes leading thereto, it is necessary to ensure that hiding places for vermin are reduced to a minimum. A pipe fixed on a backboard plugged to the wall provides harbourages both behind

the board and the pipe. Pipes and conduits should be fixed in a position clear of the walls. Where this is impossible, they should be thoroughly chased into the wall beneath the plaster. Hot-water systems should be placed as close to the bathroom as possible in order to save unnecessary piping. The common practice of using a wooden block for light fittings and switches should be discouraged, metallic or plastic units being much more satisfactory. Walls should not be papered, but painted or distempered, until at least three years have elapsed. Iron pipes built into the party walls of houses are often to be found used as brackets for supporting the hot-water tanks in the cupboards of the adjoining houses. These are sometimes left unplugged, leaving a direct communication between the two premises.

Measurement of Cubic Space. The authors do not wish to insult the intelligence of their readers by instructing them as to the manner in which cubic space should be measured. What they do wish to emphasise is the real necessity of calculating the cubic space of rooms in order to ensure that houses are correctly fumigated and that a sufficient concentration of gas is supplied. One point with regard to measurements must be stressed. In measuring rooms, deductions should never be made for chimney-breasts and other fixtures. This will enable a greater concentration of fumigant to be obtained, resulting in increased efficiency.

Conversion Tables. A knowledge of temperature conversion tables and metric equivalents is essential in scientific fumigation work. A practical selection of the tables in most common use is set out below.

Temperature Conversions

(1) To convert degrees Fah. above 32° F. to degrees Centigrade, subtract 32 and multiply by $\frac{5}{9}$.

(2) Between 0° and 32° F., subtract from 32 and multiply by $\frac{5}{9}$.

(3) To convert degrees Centigrade above 0° to degrees Fah., multiply by $\frac{9}{5}$ and add 32.

Or $\text{C.} = \frac{5(\text{F.} - 32)}{9}$ and $\text{F.} = \frac{9\text{C.}}{5} + 32$.

(4) Between 0° and − 17·77° C., multiply by $\frac{9}{5}$ and subtract from 32.

(5) Below − 17·77°, multiply by $\frac{9}{5}$ and subtract 32.

Metric Equivalents and Conversions

When dealing with metric equivalents it is necessary to remember that while the gram is the metrical standard of weight, the cubic centimetre is the standard of liquid and gaseous measure.

Liquid Measure

1 litre = 1,000 cubic centimetres.
1 c.c. of distilled water at 4° C. (39·2° F.) weighs 1 gram.
1 litre of water weighs 1 kilogram or 1,000 grams.

1 litre of water	= 35·196 fluid ounces.
	= 61·027 cubic inches.
	= 1·7598 pints.
1 gallon	= 4·546 litres.
	= 8 pints.
1 pint	= 568·34 cubic centimetres.
	= 20 fluid ounces.

6·235 gallons = 1 cubic foot.
= 1,000 fluid ounces.

To convert gallons to litres, multiply by 4·54596.
To convert litres to gallons, multiply by 0·22.
To convert pints to litres, multiply by 0·5679.
To convert litres to pints, multiply by 1·76.

Cubic Measure

1,728 cubic inches = 1 cubic foot.
27 cubic feet = 1 cubic yard.
1 cubic metre = 35·3 cubic feet.

To convert cubic feet to cubic metres, multiply by 0·0283.

Length

1 metre = 39·3701 inches.
= 1·0936 yards.
1 yard = 0·9143992 metres.

To convert feet to metres, multiply by 0·3047.
To convert metres to feet, multiply by 3·28.
To convert inches to metres, multiply by 0·0254.
To convert metres to inches, multiply by 39·37.

Square Measure

144 square inches = 1 square foot.
9 square feet = 1 square yard.
1 square metre = 10·764 square feet.
= 1,550 square inches.

To convert square feet to metres, multiply by 0·0929.

Weight

1 ounce = 28·35 grams.
1 lb. = 453·6 grams.
1 gram = 0·0353 ounce.
1 kilogram = 35·3 ounces.
= 1,000 grams.

CHAPTER VII

GASEOUS FUMIGANTS

Introductory. Fumigation, which does not merely consist of the solemn ritual of burning a sulphur candle, may be defined as follows :—

"Fumigation is a process of sanitary significance in which a lethal gas is enclosed in an enclosed space to destroy all stages of insect life."

There is nothing really difficult in the application of the process when it is carried out by competent operators, but an individual cannot be considered competent unless he is thoroughly familiar with the gases used and their respective properties, besides possessing adequate knowledge as to the correct method of using such gases. Lack of this knowledge is the most common cause of failure. For the above reasons, fumigation, which can be really interesting, should never be left in the hands of casual, unskilled labour, but should be carried out only by those fully qualified by training.

In practice, fumigation is the best method of destroying insect pests, since gaseous penetration is considerably more effective than that attained by spraying liquids.

The various gaseous fumigants which may be and are commonly used for the destruction of insect pests, are as follows :—

(1) Hydrogen cyanide.
(2) Orthodichlorbenzene.

(3) Heavy naphtha.
(4) Ethylene oxide.
(5) Sulphur dioxide.
(6) Formaldehyde.

In addition, various proprietary gaseous fumigants are often used. These will be dealt with later in the chapter.

(1) HYDROGEN CYANIDE. So much has been written regarding the dangerous nature of hydrogen cyanide that most people look upon it with fear. The fumigation of premises with this gas should certainly not be attempted by unskilled operators who have no practical experience of its use. It must continually be borne in mind that hydrogen cyanide is an exceedingly dangerous poison gas, in the handling of which every precaution must be taken. This fact, however, should not be allowed to stand in the way of promoting its more extensive use. Indeed, the value of hydrogen cyanide as an eradicator of vermin has never been sufficiently recognised.

This fumigant may be obtained either in the form of a colourless gas somewhat lighter than air (hydrocyanic acid gas), or as a colourless mobile liquid which is converted from the gas at low temperatures (below 26·1° C.) and under high pressure (hydrocyanic acid). This liquid readily assumes gaseous properties. It is known under a variety of names of which prussic acid is the most common, and was first discovered in 1782, being prepared from Prussian blue. It possesses a molecular weight of 27·03, while, at temperatures below 17·8° F., the specific gravity is 0·699. The gas possesses remarkable powers of penetration.

The liquid has a low vapour pressure of 455 millimetres at 15° C., boiling at 26·1° C. and solidifying at

− 13·4° C. The gas burns with a pale blue flame, while 12 volumes per cent. in air forms an explosive mixture. Such high concentrations are not, however, possible in ordinary fumigation work owing to diffusion and leakage. Hydrogen cyanide is a weak acid, comparatively inert and non-corrosive. As a gas it has no injurious effect upon textiles, paint work or metals. As a liquid it is miscible with water, alcohol, ether and other liquids, and will dissolve many synthetic materials such as artificial silk. Solutions in water over a strength of 50 per cent. will burn readily. Water or alkaline impurities in liquid hydrogen cyanide will cause decomposition. Such decomposition is indicated by loss of strength and discolouration, the loss varying directly with the degree of discolouration present. When decomposing, it changes from light yellow to yellow, brown to black, finally becoming a solid black mass which generally possesses a distinct ammonia smell. To prevent this decomposition, stabilisers in the form of oxalic or phosphoric acids are usually added. Decomposition is almost invariably accompanied by the generation of heat and the evolution of ammonia and nitrogen gases. Sufficient pressure may be exerted by decomposition to burst the container, and for this reason heavy containers are employed for transport of the gas. In temperate climates, the free space usually left in the container is 8·6 per cent. of the total capacity, while in tropical climates, this space is increased to 8·9 per cent. Precautions are also taken to ensure that the internal pressures of the containers remain very low, the following being the optimum pressures :—

(*a*) 15 lb. per square inch at 78° F.
(*b*) 30 lb. per square inch at 122° F.

In prepared forms, such as Zyklon, or Celophite Units, the pressure is less.

The rate of evaporation of the liquid is largely dependent upon temperature. All gases expand when heated. Thus, the greater the heat of rooms, the quicker will the gas be evolved and diffused. The gas is said to possess the characteristic smell of bitter almonds, but in many instances this is not readily discernible. In order to assist in its detection, Zyklon is combined with a lachrymatory or warning gas. Ideal warning gases should possess a similar vapour density and specific gravity to hydrogen cyanide, but unfortunately such gases have not yet been found. Hydrogen cyanide diffuses 1·5 times as fast as cyanogen chloride, often combined with it for warning purposes, and twice as rapidly as chlorpicrin. Further, such gases may be "aired out" before the hydrogen cyanide diffuses. The concentration of irritant gases is never high enough to cause an irritant effect on human beings. These gases are definitely of value, since they do give warning, especially in the case of an escape of gas by means of some undetected opening between adjoining premises.

Hydrogen cyanide possesses the following advantages :—

(*a*) It is highly poisonous to insect life.
(*b*) It does not affect textiles.
(*c*) It is readily removed from the atmosphere by ventilation.
(*d*) It has great penetrative qualities.

It has certain obvious disadvantages, however, as follows :—

(*a*) It is highly toxic to human beings, respirators being essential for the operators.

(*b*) As previously indicated, its presence in the atmosphere cannot readily be detected.

It must be stressed here that hydrogen cyanide does not always kill insects immediately. It first causes a form of paralysis, and, if the affected insects are able to migrate into the open air, they may readily recover. Cockroaches display this remarkable recuperative property to a high degree. The bed-bug is affected in different ways. The eggs are easily destroyed, as are nymphs. The greatest susceptibility seems to occur at temperatures between 60° and 80° F.

In practical fumigation, liberation of the gas may be brought about in a variety of ways :—

(*a*) Pot method (hot vapour).
(*b*) Cyanofumer (hot vapour).
(*c*) Liquid hydrogen cyanide.
(*d*) Liquid atomisation (sprayed liquid).
(*e*) Liquid vaporisation (hot plate method).
(*f*) Zyklon (dry).
(*g*) Celophite units (dry).

(*a*) *Pot Method.* This is the original method of producing cyanide gas which has not changed during the last forty years. Incidentally, it is an exceedingly crude method, not in accordance with modern scientific principles. Calculated quantities of water, sulphuric acid and sodium cyanide are placed in a vessel, the assumption being that the hydrogen cyanide which is developed will distribute itself in a sufficiently even concentration. The proportionate quantities of materials used are :—

1 ounce sodium cyanide (96–99 per cent. purity).
1½ fluid ounces sulphuric acid (S.G. 1·84).
2 fluid ounces water.

These quantities are capable of dealing with 100 cubic feet, the cubic capacity of the room having been previously determined.

The mixture is placed in a generating crock, sufficiently strong to withstand the heat developed. The crock should have a capacity at least two-thirds greater than the quantity of water and acid used, in order that the contents will not boil over when the sodium cyanide is added. In mixing the chemicals, the water is measured and placed in the crock, this being followed by the measured quantity of acid. *Acid should always be added to water as the pouring of water into acid results in violent reaction, with the possibility of serious burns.* There should always be sufficient liquid in the generating crock to cover the sodium cyanide. The temperature of the mixture rises rapidly. Before it cools, the correct quantity of sodium cyanide is added. A heated solution is necessary for complete generation of the gas. When the sodium cyanide comes into contact with the mixed liquids, a violent reaction occurs and a hot gas, laden with water vapour, nitrous fumes and sulphuric acid, is given off. The gas is generated slowly and possesses an initial tendency to rise, afterwards diffusing downwards at a slow rate. A common practice is to weigh the sodium cyanide beforehand, the material being wrapped in paper, so that, by the time the acid has eaten through several layers of paper and attacked the cyanide, the operator has had ample time to leave the room.

After the gas has been generated, a bluish liquid remains as residue in the base of the crock, together with a layer of sodium sulphate crystals. Some 10–12 per cent. hydrogen cyanide is present in solution in this liquid, the disposal of which is attended by a certain

degree of risk. The treatment of this residue with sodium carbonate will neutralise the acid, but in practice it is usually buried without further treatment.

When the pot method is employed, the gas is unevenly distributed. As the moisture content is high, there is also increased absorption by furniture and walls. Considerably more time is thus required for ventilation of the premises and the furniture, particularly upholstered material.

(*b*) *Cyanofumer.* This method was really designed to meet the needs of the agriculturist, and should not be used for house fumigation. The machine consists of two metal tanks, one above the other, the whole being fixed in a frame and mounted on wheels. The lower tank is filled with equal parts of sulphuric acid and water, while the upper receptacle contains a solution of cyanide and water. By means of a specially designed pump, operating on a graduated pillar, measured quantities of cyanide solution are forced into the acid tank, the gas which is generated being distributed through a flexible hose. The gas is emitted in hot, vaporous fumes.

(*c*) *Liquid Hydrogen Cyanide.* Liquid hydrogen cyanide, as sold for disinfestation work, usually possesses a purity of 95–98 per cent., and is transported in heavy steel containers of various sizes. The specific gravity of the liquid may be used to gauge its purity. The specific gravity of 96 to 98 per cent. liquid hydrogen cyanide should be as follows :—

(i) At 0° C. should not be higher than 0·731
(ii) At 15° C. " " " " 0·710
(iii) At 25° C. " " " " 0·695

Methods of applying the liquid vary according to individual taste. In one method employed, bottles of

liquid cyanide are inverted, the lips of the bottles being raised slightly above the bases of shallow trays. When sufficient liquid to cover the lips of the bottles has run into the trays, the flow from the bottle automatically ceases. The evaporation of the liquid in the trays regulates the flow from the bottles. If the temperature is not suitable, the gas will be unevenly distributed. It is advisable to raise the temperature of the rooms to be fumigated by means of some form of portable heater, in order to obtain an even distribution of the gas. Twenty-five ounces of hydrogen cyanide will give two volumes per cent. in 1,000 cubic feet.

Liquid hydrogen cyanide containers are packed in metal drums and are surrounded by lime and cork chips, in accordance with Home Office Regulations. These drums are transported as part of the deck cargo of ships, finally finding their way by road to their destination. The containers possess three seals. The outer seal is of lead and wire. Beneath this is a cap, which is opened with a special key. Removal of this discloses a third cap, requiring a different type of key for removal. The containers are exceptionally strong and cannot readily be damaged.

(*d*) *Liquid Atomisation.* The spraying of liquid hydrogen cyanide gives more uniform results than does the method described above. There is also better distribution of the gas, the air space being more quickly filled. The liquid is pumped through atomising nozzles and delivered as a finely divided spray. The finer the atomisation, with a consequently greater exposure of liquid surface, the more rapid will the increase in the rate of evaporation be. This method possesses the great advantage of leaving no residue for disposal.

(*e*) *Liquid Vaporisation.* This method is used in disinfestation chambers and in some forms of van fumigation. The liquid hydrogen cyanide is converted into a warm gas before or during introduction by one of the several existing methods. The most usual type of vaporiser is a small hopper containing an electrically heated plate, situated at one extremity of a large gas-tight container, the heated gas rapidly penetrating all articles to be treated. This is one of the most satisfactory methods of applying liquid hydrogen cyanide, since it gives a high initial gas concentration.

(*f*) *Zyklon.* Zyklon, which is a proprietary article, contains three separate constituents; one, a prepared, inert, porous earth known as Kieselguhr, in which has been absorbed liquid hydrogen cyanide; two, a lachrymator; and three, various stabilisers which render the chemically unstable liquid hydrogen cyanide stable. The specific weight of the gases involved is slightly lower than that of air.

This compound has an appearance somewhat similar to that of granulated cork and is dry and cold to the touch. It is packed in gas-tight tins, each tin containing a definite quantity of available hydrogen cyanide, stated on the label. Three hundred and sixty grams can be taken as evolving 1 volume per cent. in 1,000 cubic feet of air. The tins are opened by means of a special, heavy, pointed hammer, an aperture being driven in the lid. The material is distributed as desired. It can be strewn in any situation, being harmless to ordinary household materials. Usually, however, it is placed on sheets of paper, so that it may be easily collected after fumigation has been completed. The residue is entirely harmless and may be disposed of in the domestic

dustbin, though it should first be burnt to ensure that no residual hydrocyanic acid gas is present.

This form of application possesses the following advantages :—

(i) The presence of a lachrymator provides an additional measure of security both during and after actual operations.
(ii) No cumbersome apparatus is required. This obviates complicated and dangerous manipulation.
(iii) Transport and handling costs are reduced to a minimum, while the product is well packed in very light but strong containers.
(iv) Being a dry gas, Zyklon has no injurious effects upon household goods.
(v) It is highly toxic to all forms of insect life in suitable concentrations.
(vi) It possesses remarkable penetrative powers.
(vii) It is easy to distribute, while rapid, maximum concentration is obtained owing to speedy exudation of the gas from the large surface area of material exposed.
(viii) The dosage is easily controlled.
(ix) The gas is easily dispersed by ventilation.
(x) The residues are harmless, while their disposal is simple.

(*g*) *Celophite Units.* The use of units is generally termed the unit method of fumigation. Liquid hydrogen cyanide is absorbed in thin, fibrous discs composed of *papier mâché.* The absorbent is acidified. This serves as a stabiliser, while the discs act as carriers for a predetermined quantity of the gas. They are each approximately $5\frac{3}{4}$ inches in diameter and $\frac{5}{16}$ inch in thickness, and contain 1 ounce of liquid hydrogen cyanide. Each disc represents 0·1 per cent. dosage for a space of 1,000 cubic feet ; 1 cubic foot of gaseous

hydrogen cyanide being evolved at normal temperatures. The discs are whitish in colour and damp to the touch. Warning gas may or may not be included, as desired. Each disc weighs approximately 1 ounce and is packed in a tin, similar to the large-size Zyklon containers, although smaller sizes are available. One size contains sixteen discs weighing 16 ounces, while the larger size contains forty discs and weighs 40 ounces. The containers are constructed of heavy-gauge, printed tinplate, non-corrodible lacquer lining the interior. The words " POISON GAS " are embossed at each end of the tins and this forms an indestructible warning as to the contents. The quantity of hydrogen cyanide required to give the desired concentration is first determined, the desired number of cans being afterwards allocated.

The tops of the cans are cut by means of a special cutter. The discs are placed in various parts of the room or van, the hydrogen cyanide being quickly liberated into the atmosphere. The discs possess a big advantage in the facility of handling, although perhaps this is hardly an advantage as the careful avoidance of handling articles saturated with liquid hydrogen cyanide is to be advised wherever possible. It might be pointed out that there is a tendency for the hydrogen cyanide to linger in the material and for the liquid to separate out in the cans. The transport of hydrogen cyanide in canisters containing discs of this type introduces no dangerous features. Only the top surface of the disc is directly exposed to the atmosphere and this surface permits the liquid hydrogen cyanide to volatilise rapidly, an extremely important factor. On the other hand, unnecessary absorption of the gas often occurs by whatever material on which the disc rests. In fifteen to

twenty minutes the gas under normal conditions expands 1 cubic foot.

The *toxicity* of hydrogen cyanide is always recorded in terms of "volume per cent." Owing to the difficulty of rendering a room completely gas-tight, the full concentration of gas is seldom attained. The recommended concentration is 1 volume per cent. (1 volume of gas in 100 volumes of air). This is obtained by using 12·5 ounces of hydrogen cyanide in 1,000 cubic feet for a period of three hours.

Certain *calculations* are essential to efficient operation. These are detailed below.

To convert "Grams of H.C.N. per 1,000 cubic feet" to "Volumes of gaseous H.C.N. per cent."

Molecular weight of H.C.N. = 27
(H = 1 ; C = 12 ; N = 14)

The molecular weight of *any* gas in grams occupies 22·3 litres.

27 grams H.C.N. occupy 22·3 litres

$$1 \text{ gram H.C.N. occupies } \frac{22{\cdot}3}{27} \text{ litres}$$

1 litre	= 1·76 pints
8 pints	= 1 gallon
6·235 gallons	= 1 cubic foot.

Thus

$$\frac{22{\cdot}3}{27} \text{ litres} = 22{\cdot}3 \times 1{\cdot}76 \times \frac{1}{6{\cdot}235} \text{ cubic feet}$$

$$= \frac{39{\cdot}25}{1346{\cdot}7} \text{ cubic feet.}$$

$$1 \text{ gram of H.C.N. occupies } \frac{39{\cdot}25}{1346{\cdot}7} \text{ cubic feet.}$$

To convert "grams per 1,000 cubic feet" to "volumes per cent."

The stated number of grams is divided by 10 to find the "grams per 100 cubic feet." This number of grams is then multiplied by $\frac{39 \cdot 25}{1346 \cdot 7}$ to find the "volume per cubic foot," which they occupy. Since the volume is contained in 100 cubic feet of space, this last figure is the "volume per cent." Thus, to convert "grams per 1,000 cubic feet" to "volumes per cent," multiply by $\frac{39 \cdot 25}{1346 \cdot 7}$ *or* 0·00292.

To convert "volumes per cent." of gaseous H.C.N. to "volumes per cubic foot."

The stated number of "volumes per cent." is multiplied by 10 to give "volumes per 1,000." The figure obtained may be expressed in cubic feet, and, when converted into grams, will give the required "grams per 1,000 cubic feet."

To convert volumes of gaseous H.C.N. to grams.

(i) Volume by 6·235—to gallons.
(ii) Then by 8 —gallons to pints.
(iii) Divide by 1·76 —pints to litres.

$$10 \times \frac{6 \cdot 235 \times 8}{1 \cdot 76}$$

Since 22·3 litres of H.C.N. gas weigh 27 grams

1 litre of H.C.N. gas weighs $\frac{27}{22 \cdot 3}$ grams,

by further multiplying the "volume" by $\frac{27}{22 \cdot 3}$, the equivalent in grams is obtained. The factor then becomes :—

$$\frac{6 \cdot 235}{1 \cdot 76} \times 8 \times 10 \times \frac{27}{22 \cdot 3}$$

$$= \frac{13467}{39 \cdot 25}$$

$$= 343.$$

The figure usually taken is 360. This is used in order to counteract any complications which may arise.

Notes

(1) (i) References to ounces of H.C.N. mean fluid ounces.
(ii) References to ounces of calcium cyanide mean avoirdupois ounces.

Minimum dosages are :—

(2) $\frac{1}{2}$ volume per cent. H.C.N. kills all stages of bed-bugs in five hours.
1 ,, ,, ,, ,, ,, ,, of bed-bugs in three hours.
2 ,, ,, ,, ,, ,, ,, of bed-bugs in two hours.

Longer exposures may be necessary according to the amount of absorbent material present.

(3) The minimum fumigation period with H.C.N. should be two hours. Shorter dosage periods facilitate ventilation. A temperature of at least 60° F. is necessary to increase diffusion of the gas and increase insect metabolism.

In van fumigation, a temperature of 60° F., with a period of four hours, is usual.

In treating houses, a longer period of exposure is necessary.

The greater the concentration, the more gas will be absorbed, with a consequent slow clearance of the room after treatment.

As already indicated, *temperature* is exceedingly important where hydrogen cyanide is concerned, rapid evolution and quick diffusion of the gas evolved being essential to success. To obtain such conditions some form of heat is often necessary. In the case of van fumigation this is readily obtained. Heat is not commonly used in house fumigation unless the temperature of the premises falls below 60° F. When required, the preheating of rooms can be arranged by means of small primus stoves, or, where possible, by means of

electric radiators. By such means the temperature of a room can be raised 20° F. in about two hours.

Cyanide in any of its forms should be stored apart from acids, preferably in a special brick-built store which should always be kept locked. A shady position should be chosen as site for the store, while a tall shaft should be provided for ventilation purposes, to allow for the possibility of any leakage from the containers.

(2) ORTHODICHLORBENZENE. Orthodichlorbenzene was extensively used for the disinfestation of property until a short time ago. Following the recommendation of the Ministry of Health that its use in occupied houses should be prohibited, however, it is now only employed in empty houses, particularly in slum houses awaiting demolition. It can be used in circumstances where hydrogen cyanide would be ineffective and possesses the following advantages :—

(*a*) As a contact spray, it is as efficient as any other insecticide.

(*b*) The vapour kills all insect forms and eggs in positions where a contact spray would be unable to penetrate.

The greatest disadvantage lies in its effect upon animals and human beings, physiological changes such as fatty degeneration of the liver and necrosis of the kidneys being produced. Orthodichlorbenzene has a peculiar action upon the bed-bug, causing the insect to bolt from its hiding-place. It is cheap and economical in use, one gallon being sufficient for each 1,000 cubic feet. When used alone it gives a fair percentage of success, being sufficiently toxic to kill vermin. Its vapour is not, however, sufficiently penetrative. When mixed with an equal quantity of carbon tetrachloride it is more successful, although the presence of the

latter chemical exerts a destructive effect upon paintwork, damage to furniture and linoleum sometimes resulting. If the mixture is used in houses awaiting demolition, this disadvantage, of course, would not be apparent. Two parts of orthodichlorbenzene may be successfully mixed with 1 part of methylene chloride, while methylated spirit may be used in place of methylene chloride with satisfactory results. White spirit, which assists the mixture to spread further, may be used in similar proportions. Such liquid mixtures may possess a strong smell, which, although not unpleasant, tends to linger for several days. The addition of crude phenol will somewhat mask the odour, 4 ounces to each gallon of mixture being sufficient for this purpose. When this mixture is used, woodwork need not be removed.

Although the materials just described, together with heavy naphtha, are liquids, their action depends upon the vapour liberated. For this reason the use of respirators is necessary when spraying is in progress. These fluids are poisonous and their vapour will taint foodstuffs.

(3) HEAVY NAPHTHA. Heavy naphtha, which is a product of tar distillation, is a clear, colourless liquid with a characteristic but not unpleasant smell. It is a complex mixture of aromatic hydrocarbons with their associated bodies, the particular constituent or combination of constituents lethal to the bed-bug being still unknown.

The major constituents are :—

(*a*) Pseudocumene.
(*b*) Mesitylene.
(*c*) Tetramethylbenzene.
(*d*) Cumarone.
(*e*) Indene.

Small quantities of naphthalene, thiopen and methylpyridines are also present.

The standard specification of heavy naphtha is as follows :—

(*a*) *Colour*. Shall not be darker than a freshly prepared solution of 1 millilitre of N/10 iodine in 1,000 millilitres of distilled water.
(*b*) *Specific Gravity*. The specific gravity shall not be less than 0·835 and not exceed 0·910.
(*c*) *Water*. Shall be free from water and other invisible impurities at 15·5° C.
(*d*) *Distillation Range*. Method as defined in B.S.I. specification No. 479 for coal-tar naphthas. Up to 160° C., shall not exceed 5 millilitres. Up to 190° C., shall not be less than 90 millilitres.
(*e*) *Flash Point* (*Abel*). Shall not be less than 105° F.
(*f*) *Tar Acids and Bases*. Shall not exceed 0·25 per cent.

The vapour given off by heavy naphtha is fatal to the bed-bug and other insects.

The lethal dose is governed by air temperature. The following table illustrates this point, showing the connection between temperature and saturation concentration.

TABLE I

		Per cent. volume
At 40° F.	Saturation concentration in air	0·12
At 50° F.	,, ,, ,,	0·16
At 65° F.	,, ,, ,,	0·33
At 72° F.	,, ,, ,,	0·39
At 80° F.	,, ,, ,,	0·50

The necessity of a high initial temperature when heavy naphtha is applied must be emphasised. Only where the air temperature of the coolest rooms in the house lies between 70° and 80° F. should heating be dispensed with, while temperatures up to 90° F. may be employed when the material is used.

The quantity required to yield optimum concentration is 2 gallons per 1,000 cubic feet of room space, and the cost is reasonable.

Heavy naphtha is not completely efficient. It should be remembered, however, that heavy naphtha as a vermicide is still in the experimental stage, and that improvement in technique as the result of experiment will probably increase the efficiency percentage. The vapour is readily absorbed by porous surfaces and, while toxic to vermin, is harmless to human beings. Because of the heavy concentrations used, gas masks must be worn to prevent difficulty in breathing and subsequent discomfort, while no naked lights should be permitted in rooms where the vapours of heavy naphtha are present.

(4) ETHYLENE OXIDE. Ethylene oxide is a colourless liquid which boils at 52·7° F. and has a specific gravity at 4° C. of 0·896. Because of its low boiling point it readily becomes gaseous at ordinary room temperatures. Its molecular weight is 44·03, its freezing point is − 140° C., while the flash point is − 42° C. The liquid is soluble in water and certain other solvents, and possesses a faint but distinct ether-like smell.

The process of manufacture is secret, but it may be prepared by passing ethylene and carbon dioxide through a solution of bleaching powder in water. It is used as an alternative to hydrogen cyanide. Although ethylene oxide is an active ingredient, the actual substance used commercially for disinfestation work is a mixture of ethylene oxide and carbon dioxide in varying proportions known as "ETOX." This mixture can be stored indefinitely without reaction or deterioration of its insecticidal properties.

The presence of carbon dioxide simplifies handling and increases the toxicity by stimulating the respiratory organs of insects. In addition, the danger of fire is reduced. Carbon dioxide also increases the absorption of the toxic fumigant and assists in the expulsion of the ethylene oxide from the cylinders in which the mixture is contained.

Gaseous ethylene oxide does not possess sufficient odour to give distinct warning of harmful concentrations. It does, however, cause intense irritation to the eyes and nose when present in high concentrations, and moderate though distinct irritations in safe concentrations. Because of its low boiling point the gas is effective at comparatively low temperatures, while it possesses great penetrative powers. Owing to this property it is used in the destruction of insects in flour and other dense foodstuffs. It is less toxic than hydrogen cyanide, but more toxic than carbon tetrachloride or sulphur dioxide, possessing a toxicity 250 times greater than the latter substance. Inhaled for lengthy periods, it will produce, in human beings, a form of cyanosis which is counteracted by the administration of carbon dioxide gas.

The advantages to be derived from the use of ethylene oxide may be summarised as follows :—

(i) It is chemically inactive.
(ii) It will not bleach materials.
(iii) It is highly penetrative.
(iv) It possesses satisfactory powers as an ovicide.
(v) It does not affect foodstuffs.
(vi) It is highly toxic to insects and a guaranteed lethal agent.

Its great disadvantage lies in the fact that the gas burns readily, while, in addition, it is expensive, being

50 per cent. more costly than hydrogen cyanide, although labour costs are less. The concentration employed in house fumigation is 1,500 grams per 1,000 cubic feet for twenty-four hours. Its vapour is approximately 1·6 times heavier than the air. When mixed with water, glycol is formed.

In this country, ethylene oxide is available commercially under the name of "Etox," which is composed of 90 per cent. ethylene oxide and 10 per cent. carbon dioxide. Its efficiency depends upon :—

(i) Temperature. This must be above 60° F., as absorption is greater at low temperatures.
(ii) Concentration. This depends upon the insect to be destroyed, the materials to be treated, and the time of exposure.
(iii) Time of Exposure. This is usually twenty-four hours.
(iv) Nature of Material to be Treated. This influences the efficiency of the fumigation, as different types of material absorb the gas to variable degrees.

"Etox" is contained in steel cylinders, being diffused by means of flexible copper tubes through a fine jet. This jet may be inserted through the keyhole in the door of the room to be treated, or through a special aperture made for the purpose or by releasing a container holding the required quantity of fumigant for the space to be fumigated. The gas is discharged in an upward direction and emerges in the form of a fine mist. A gas mask is, of course, necessary. Its cost has, up to the present, prevented its extensive use by local authorities for the extermination of vermin in buildings.

(5) Sulphur Dioxide. Sulphur is a simple element of ancient usage, having been known to and valued by

the Egyptians. It is a yellow or white solid possessing no taste or smell, and, in its simple form, exerting very little influence upon man. It is exceedingly brittle and is a poor conductor of heat. Its density is 1·6–2·06, melting point being 115° F. It is insoluble in water, is sparingly soluble in alcohol, ether, etc., but is readily soluble in carbon disulphide. When burned in air, a characteristic blue flame is observed and sulphur dioxide and sulphur trioxide are given off. It exerts a choking effect upon insects, and, in this form, is poisonous to human beings. It is much heavier than air.

Sulphur dioxide is a colourless gas which possesses a choking smell and is soluble in water, forming sulphurous acid. This acid will readily tarnish certain metals. In the presence of moisture, sulphur dioxide is a bleaching agent, the strength of the materials bleached often being affected.

Sulphur dioxide may either be used prepared in the form of a gas, or may be generated in the premises by burning sulphur in the rooms to be treated. Because of its heavy nature it diffuses very slowly and it possesses poor penetrative powers. It cannot be depended upon to destroy eggs and insects situated in deep crevices, two applications being therefore essential unless much preparatory work is carried out. The surfaces of metals should be treated with grease to prevent discolouration.

The dosage recommended by the manufacturers of sulphur blocks (usually 1 lb. per 1,000 cubic feet) and the period of exposure (generally four hours) is inadequate, at least 6 lb. per 1,000 cubic feet being necessary, with an exposure period of six to eight hours. This dosage should be increased to 8 lb. per 1,000 cubic feet if any leakages are suspected. Sulphur may be

employed in the form of blocks, candles, powder or as rock sulphur, the latter being ignited by means of wood chips and paper. The block or candle is easiest to use for room fumigation, being ignited easily with the assistance of methylated spirit. The sulphur blocks, which should stand in a dish surrounded by water to prevent any risk of fire, should be placed throughout the room to be treated at different levels to assist diffusion. Flowers of sulphur combined with a small quantity of potassium nitrate may be mixed as required by the operators. The mixture will ignite and burn quickly, with rapid emission of gas. The cost per room by this method, if the materials are mixed by the persons using same, is very low. Sulphur dioxide in cylinders may be used if desired (see p. 135).

This gas does not appear to be more than 90 per cent. efficient after two applications. Its efficiency may, however, be increased if the temperature of rooms is raised. Ventilation after fumigation with sulphur dioxide is difficult, and is, moreover, rarely carried out in a thorough manner. Rooms should be ventilated for at least twelve hours.

(6) FORMALDEHYDE. Fumigation with formaldehyde is laid down as the standard method to be adopted in the Regulations for the Army Medical Services. Formalin is placed in a galvanised iron pail, chloride of lime wrapped in thin paper, which is then pierced, being quickly added. A violent chemical reaction immediately takes place, 80 per cent. of the formaldehyde being vaporised by the heat of the primary reaction. The treatment is most effective at a temperature of 70° F. with an atmospheric moisture content of 70 per cent., when even insect eggs appear to be rendered sterile.

The container should be placed as close to the ceiling as possible, in order to facilitate diffusion of the gas. At least 2 pints of formaldehyde and 2 lb. chloride of lime are required for each 1,000 cubic feet of space. The time of exposure is twenty-four hours. The person opening the room after fumigation should wear a gas mask.

Many *proprietary fumigants* possess sulphur as a base. Three of the most popular are described below :—

(*a*) Sulphume.
(*b*) Cimex.
(*c*) Bromar Gas.

(*a*) SULPHUME. Sulphume is the gaseous product of burnt sulphur, from which all impurities have been removed by washing with water. After washing, the gas is compressed into the liquid state and is stored in light metal cylinders containing 12, 20 or 70 ounces. In this form it is ready for immediate use. It is not inflammable, but, as the gas is under pressure, the cylinders should be stored in a cool position.

To discharge the liquid gas the vent tube at one extremity of the container is pierced. The gas immediately begins to discharge, after which the container is placed vent downwards into an earthenware basin in which a damp cloth has been placed. The cloth maintains the cylinder in position, while the moisture assists in hydrating the gas. It might, however, be stated that there is usually sufficient water vapour in the atmosphere of this country to hydrate the charge.

On liberation, sulphume resumes its gaseous state, becomes intensely cold, and is correspondingly heavy. It flows about the floor and lower part of the room,

ascending towards the ceiling as it absorbs warmth. A 70-ounce canister should be used for each 1,000 cubic feet. There is no risk of fire with this method, and the makers claim a greater efficiency than is obtained by burning sulphur in a room. In addition, metals are not tarnished, as the causal impurities are eliminated during production. Sulphume is said to possess high penetrative powers, which are increased if the room is heated prior to liberation of the gas. Diffusion is also increased in the same manner.

(*b*) CIMEX. Cimex, which has a sulphur base, is a popular type of fumigating block. It is claimed that one block is sufficient for 1,000 cubic feet of air space, but, when compared with sulphur, the material is not inexpensive. The gas given off is said to possess remarkable penetrative powers and to be lethal to all insects.

(*c*) BROMAR GAS. This is a special form of sulphur dioxide, claimed by many to yield very satisfactory results. A 15–20 per cent. concentration at a temperature of 75° F. with an oxygen-absorbing medium is usually recommended, an efficiency of 98 per cent. being claimed. No damage is done to metals, nor are fabrics faded. A further claim made for the material is that even foodstuffs are unaffected. The gas is applied from the exterior of the room or premises, being diffused through a letter-box or keyhole. If the entire premises are to be treated, the gas is passed through the keyhole on the external door and is carried by means of rubber pipes to the various rooms. Circulators are provided inside the rooms to give constant circulation. Some form of heat is, of course, necessary in unusually cold weather.

Innumerable proprietary articles may be obtained using sulphur as a base, but generally speaking it may be stated that their powers as vermin destroyers are no better than those of sulphur, while their cost is much greater.

CHAPTER VIII

OTHER SPECIFICS

INSECTICIDES can be grouped into four main categories as follows :—

(1) Those used in vapour form. These have already been discussed in the previous chapter.

(2) Those which act by contact, in liquid form. Some members of this group give off a vapour possessing a certain penetrative power, while others contain an agent which brings out the vermin from their hiding places.

(3) Those used in dry or powdered form. Some of these generate a gas, *e.g.*, calcium cyanide, and have already been described. Other powders remain to be mentioned in the present chapter.

(4) Those used by mixing with food. These are poisonous when ingested and are generally used in the form of poison baits. These have already been discussed in Chapters III and IV.

The remaining specifics not already described which are used to combat infestation are as follows :—

(1) Liquid Insecticides.
(2) Insect Powders.
(3) Special Methods.
(4) Steam.
(5) Soap and Water.

It should be noted that these methods are not placed in the order of their efficiency. For instance, it is only

possible to use steam for the disinfestation of bedding except under special circumstances, while, if greater primary use were made of soap and water, there would undoubtedly be less infested property with which to deal.

(1) **Liquid Insecticides.** There can be little doubt that the most practical insecticides are those in gaseous form. Unfortunately, these cannot always be employed because of a variety of circumstances. Liquid, or *contact* insecticides as they are often termed, may be divided into three distinct categories, as follows :—

(*a*) Protoplasmic poisons.
Strong acids or alkalies are examples of this type.

(*b*) Oily substances.
This type chokes the respiratory spiracles of the insects.

(*c*) Substances which act upon the nervous system of the insect.
Pyrethrum may be cited as an example of such a substance.

When one considers the mixtures sold as liquid insecticides only a few years ago, it would almost seem that the lethal efficiency of an insecticide was judged by its degree of offensiveness to the human nasal organ. The researches of Standinger, however, opened up a new era. He showed, in particular, that pyrethrum flowers could yield an extract which possessed insecticidal properties. Since that time extracts suitable for this purpose have been obtained from many other plants.

Insect destruction by means of such sprays was, however, a somewhat haphazard affair, owing to the fact that the sprays were manufactured from natural products which were liable to all the inherent variations of such natural crops. In almost every instance research has indicated the approximate chemical com-

pound responsible for the lethal efficiency of any given plant, but the estimation of this compound in the raw material has invariably proved difficult, while in no case could the " toxic-body-content " be co-related to the lethal efficiency of the resulting insecticide. Furthermore, variations in the toxic-body-content, stability, quantity of crop and resulting influence on price, to mention only the more important factors, have all contributed their quota to the difficulties of producing a reliable spray.

Liquid insecticides are more freely and widely used than gases, since they are more easily and safely handled. The use of a really effective gas involves the most careful, elaborate and expensive preparations, quite apart from the disturbance caused to the tenants of the premises to be treated. Many liquid insecticides will kill an insect upon contact, and for this reason they are termed " contact insecticides." Irritant sprays not only drive the vermin into the open, but also into deep-seated and securer harbourages. Whether or not these insects emerge in a reasonable time to enable the operator to register a direct hit depends upon the nature of the harbourage.

Clearly, however, such liquids cannot be regarded as efficient. The method is " hit-or-miss," whereas the essence of efficient disinfestation is that every insect, its larvæ and its eggs should be destroyed. This cannot be done with an insecticide which fails to make contact. To compete with gas as a lethal agent, liquid insecticides must therefore borrow one important advantage held by the former agent, namely, its deep, penetrative power.

It is claimed for some insecticidal sprays that they give off a vapour which penetrates deeply, is toxic to

vermin, and is sufficiently irritating to induce such vermin to leave their harbourages and come into the open, where they may be sprayed by the direct method. Liquid sprays, however, cannot be truly classed as fumigants, as the liquid is atomised and a vapour given off. Some makers claim that this vapour is a fumigant, but it should always be remembered that, unless this vapour is present in a highly concentrated form, it cannot effectively kill vermin. It should also be remembered that there are few, if any, vapours toxic to insects which are not toxic to human beings.

Obviously the degree of efficiency of the toxic spray treatment depends almost entirely upon the thoroughness with which the spray is applied. To assist in obtaining maximum efficiency, it is usual to open up all cracks and hiding places where insects may congregate. No matter what form of spray one uses, the most potent factor governing the final result lies in the application, both as regards the method employed and the human element.

Liquid insecticides possess the advantage that they can be used in places where it is impossible or inadvisable to employ a gaseous fumigant. Efficiency is not, however, always obtained for the following reasons :—

(*a*) They are not always used to the greatest advantage, nor is sufficient care taken in their choice. One type of insecticide is often expected to act successfully on all insects, whereas greater success would be achieved if the appropriate insecticides were used for different species.

(*b*) It is essential that a liquid insecticide should be applied in the correct manner and that a sufficient concentration should be attained.

(*c*) Insecticides are often purchased without testing and

without sufficient thought being given to the purpose for which they are to be used.

To be really efficient a liquid insecticide should satisfy the following requirements :—

(*a*) It should be non-staining.
(*b*) It should be non-explosive.
(*c*) It should be non-poisonous to human beings.
(*d*) It should not corrode metals or paint.
(*e*) It should not contaminate foodstuffs.
(*f*) It should be an efficient lethal agent.
(*g*) It should not cause irritation to the eyes, nostrils or skin when used in accordance with recognised methods.
(*h*) It should consist of a base combined with a suitable active ingredient or ingredients. The base should be a liquid hydrocarbon conforming to a standard specification. In practice, this is usually a non-staining kerosene.
(*i*) The active ingredient should be toxic to the insects to which it is applied.

It must be emphasised, however, that no such liquid insecticide exists.

It will be understood from these requirements that if a liquid insecticide is to be really effective the active ingredient assumes the utmost importance. Many types of active ingredients are used, the most important being :—

(i) PYRETHRUM. Pyrethrum, one of the most common constituents of liquid insecticides, is found in the blossoms of several flowers, chief among which is the chrysanthemum. The active substances are known as pyrethrins. Pyrethrum may be ground into a powder, or the pyrethrins may be extracted with light mineral oils. The toxic properties of this substance are due to elements known as

pyrethrins 1 and 2. The method of application is of great importance. When an insecticide contains pyrethrum, it should not be allowed to remain for any length of time in contact with the atmosphere, as air exercises an oxidising effect upon the pyrethrins. Any liquid insecticide of which pyrethrum is an active ingredient should not contain less than 0·3 per cent. of pyrethrins. Many contain only 0·0025 per cent. Pyrethrum is also a common constituent of insecticidal powders. The fullest use of pyrethrins in disinfestation work has not yet been made.

(ii) DERRIS AND ROTENONE PRODUCTS. The roots of the rotenone plant are noted for their insecticidal properties. The powdered root is known as *derris root*, while the extract obtained from such roots is known as *rotenone*. Derris root is a common constituent of insect powders. Rotenone is expensive and is not toxic to warm-blooded animals or to human beings. It gradually loses its toxic properties when exposed to light and air. A liquid insecticide should not contain less than 0·1 per cent. of rotenone.

(iii) PHENOLS. Phenols possess an exceedingly penetrating smell and a strong, burning taste. They are often corrosive poisons, and may destroy fabrics and colours. The most common phenols used for insecticidal purposes are :—

(*a*) *Formaldehyde*. This is generally known as formalin solution, and is a 40 per cent. solution of formaldehyde gas dissolved in water. It is unstable, decomposing in cold weather, and, while it is a satisfactory disinfectant or germicide, the value of the solution as an insecticide is small. It will, however, kill flies, while a 1·25 to 1·5 per cent. solution will destroy fleas. As indicated in the previous chapter, formaldehyde generated by the application

of chloride of lime to liquid formalin appears to have been tried as an insecticide.

(b) *Methyl Salicylate.* This is commonly known as oil of wintergreen. It is of little or no use as an insecticide.

(c) *Essential Oils.* The essential oils such as heliotrope, thymol, citronella, cedarwood oil and vanilla possess no insecticidal value. They are often added to insecticides to cover up the smell of an offensive-smelling base. They may, however, be used as fumigants.

(iv) CHLORINATED HYDROCARBONS. These are potent insecticides, being toxic to all forms of insect life. *The use of a chemical of this type is, however, to be discouraged, as the inhalation of small quantities of the active agent causes physiological changes in human beings.*

(v) LETHANE 384. Lethane 384 is an American discovery which has recently been placed upon the market. It is an insecticide concentrate designed specifically as the active agent of a liquid insecticide. It is neither an extract, a by-product, nor a simple mixture of ordinary chemicals, belonging to a class of compounds known as aliphatic thiocyanates. The elements entering into the composition of these compounds are carbon, hydrogen, oxygen, sulphur and nitrogen. No elements which are basically poisonous are involved in its composition. Lethane possesses many advantages which may be summarised as follows:—

(a) It is stable, keeping indefinitely without deterioration.

(b) It possesses good ovicidal properties.

(c) It is non-staining when mixed with a good petroleum distillate.

(d) It is non-toxic to human beings in small quantities, but exceedingly toxic to all forms of insect life.

(*e*) It is non-corrosive.
(*f*) It is rapid in action and exerts a residual repellent action for some considerable time in rooms where it has been used.

It is usually mixed with stainless kerosene in the following dilutions :—

(*a*) Bed-bugs, moths and cockroaches . .	6 per cent. solution
(*b*) Fleas, flies and mosquitoes . . .	4 ,, ,, ,,
(*c*) Ants	2 ,, ,, ,,
(*d*) Warehouse or mill weevil	5 ,, ,, ,,

If desired, a small percentage of some essential oil may be added, to impart a pleasant odour.

A few contact insecticide prescriptions which have been used with varying degrees of success are set out below :—

No. 1.	Paraffin oil . .	50 galls.	Toxic to human beings.
	Orthodichlorbenzene .	2 ,,	
	Methyl salicylate .	1 gall.	
No. 2.	Paraffin oil . .	1,000 parts	Toxic to human beings.
	Nitrobenzene . .	2 ,,	
	Cresol . . .	2 ,,	
	Pyrethrum flowers .	10 ,,	
No. 3.	Carbon bisulphide .	1 part	Explosive and toxic to human beings.
	Kerosene . . .	20 parts	
	Mix by shaking and add :		
	Sanitas-sypol . .	7 ,,	
	A 10 per cent. solution in water is used.		
No. 4.	6 per cent. solution of mercuric chloride in 90 per cent. alcohol.		Very toxic to human beings.

No. 5. Extract 400 grams of pyrethrum with 2,000 ml. alcohol. Filter the liquid and then add :

50 grams camphor.
150 ml. cedarwood oil.
25 grams citronella oil.
25 grams lavender oil.

An average sleeping-room requires 8 to 10 oz. The dosage must be repeated fourteen days after the first spraying.

No. 6. Mercuric chloride	.	1 oz.	Toxic to human beings.
Alcohol . . .	.	$\frac{1}{2}$ pint	
Turpentine . .	.	$\frac{1}{4}$,,	

Two applications are required.

In addition to the foregoing liquid insecticides, a large number of proprietary liquids are sold under various trade names, the manufacturers claiming, in most cases, that their action is certain. Many possess a paraffin base to which an active agent of a type already mentioned has been added. It is impossible in this volume to enumerate all the varieties of proprietary insecticides upon the market.

Types of Spray. When a contact insecticide is used, it is essential that a suitable type of spray should be employed. Innumerable makes of spray of the hand, foot or electrically operated types may be obtained. The foot-operated or power-driven types are the most suitable for vermin control work. The requirements of a good spray are few but important. They are :—

(*a*) Simple in operation.
(*b*) Minimum of working parts.
(*c*) Powerful jet velocity.
(*d*) Perfect atomisation.

Electrical sprayers are suitable for use with any contact insecticide. Although originally designed for use as cellulose sprayers, they have been used with considerable success for the destruction of vermin. Foot-operated sprays will give the continuous pressure necessary to force the insecticides into cracks and crevices. They are usually simple in construction and, by means of a

slight alteration of jets, either a powerful high-pressure spray or a penetrating mist-like ejection may be obtained. They are made with varying capacities, the pressure attained being in the neighbourhood of 70 lbs. per square inch. They can be used with any type of liquid insecticide, including orthodichlorbenzene and heavy naphtha. Electrically-operated hand sprayers are quite efficient, but awkward to hold when continuously used. A small spray is used in many areas for the spraying of detectors composed of orthodichlorbenzene and methyl salicylate. This is usually carried out after disinfestation work has been completed.

The makers of many liquid insecticides have perfected their own type of sprays suitable to the requirements of their particular liquid. It might be noted here that sprays which possess rubber or leather washers cannot be used with orthodichlorbenzene or heavy naphtha, owing to the destructive action of such liquids upon the washers.

Application of Liquid Insecticides. Correct application of any insecticide is essential if success is to be achieved. In the past, too little attention has been paid to this aspect of the problem, the result being that many complaints have been received as to the effectiveness of certain solutions. The necessary steps to be carried out are detailed below :—

(*a*) All bedding, clothing, blankets, sheets, curtains, etc., should be carefully examined, all visible insects killed, and the materials placed in stout canvas bags for removal to the steam disinfector.

(*b*) Rugs, carpets, mats and linoleum should be lifted, examined carefully, removed outside and thoroughly sprayed with the insecticide. Pictures should be removed, examined and treated in a similar manner.

(*c*) Curtain-poles, brackets, runners and other window fittings should be examined before removal, visible insects killed, and the fittings taken out of doors and thoroughly sprayed.

(*d*) Any domestic animals, pets or plants should be removed from the premises.

(*e*) All heavy furniture should be carefully examined and sprayed. The floor in the centre of the room should be well sprayed, care being taken to ensure that the atomised fluid enters the space beneath the floor. If the floors are constructed of tongued and grooved boards, a certain number of the boards should be removed. The furniture should then be moved from the area around the walls to the centre of the room.

(*f*) The interior of the roof should be thoroughly sprayed.

(*g*) Architraves, window-boards, picture rails, and skirtings should be eased away from the walls, especially where a close fit obtains.

(*h*) The liquid should be sprayed into the spaces thus left and into all crevices, cracks and cupboards, nail-holes, locks, doors and mantelpieces. All crevices should receive an adequate dose. In the case of lath and plaster partitions, apertures should be bored at various points to allow the nozzle of the spray to enter. The walls and ceilings of rooms should also be sprayed.

(*i*) The beds should be taken to pieces, and all crevices, bed-ends, and spring or wire mattresses sprayed. All furniture should be examined and the interiors of the articles sprayed. If necessary, drawers should be removed to facilitate this operation. Perambulators should not be overlooked. Old furniture should, by arrangement with the tenant, be removed and burnt.

(*j*) The remaining portion of the floor should be finally sprayed, sufficient boards being removed to allow the insecticide to enter the floor space.

At least two dosages are usually necessary in the case of heavy infestations, at an interval of some five days, while a third spraying may even be required. The procedure should be similar to that outlined above. Rooms should be treated and bedding removed, if possible, in the morning. If the procedure detailed above is meticulously carried out, cases of mild infestation, and the majority of cases where infestation is more severe, will require no further treatment.

(2) **Insect Powders.** Solid insecticides, *i.e.*, powders, can be dismissed immediately from consideration in relation to the problem of bed-bugs and fleas, since such materials require to be eaten. As the only food by which the aforementioned insects are attracted is blood, preferably human blood, it will readily be understood that insect powders are of little use in the extermination. In addition, such insects are highly resistant to insecticides far more deadly than any which can be used in solid form.

All insect powders are contact insecticides, and, with certain exceptions, cannot be relied upon. The results achieved are due to asphyxiation of the insects, fine powders being blown from a small spray or blower on to their bodies or into their haunts. The powders usually contain some of the following constituents :—

(i) Borax, usually in the form of borax and sugar.
(ii) Sodium silicofluoride.
(iii) Powdered derris root.
(iv) Pyrethrum, generally combined with borax or menthol and derris root.

Paradichlorbenzene dusted on to the floor forms a satisfactory powder in the case of fleas, while powdered naphthalene may also be used for this purpose. Powdered

insecticides are more useful in the case of biting and chewing insects, and some of these toxic powders have already received mention in Chapter V.

(3) **Superheating.** Brief mention must be made of the use of superheating in the destruction of vermin in infested premises. *Superheating of rooms* has been recommended by various authorities, this method being apparently successful where it can be carried out. Criddle recommends superheating to a temperature of 125° to 145° F. for at least six hours, while Gibson has described a method by which two plasterer's stoves were used to superheat a four-roomed house. Temperatures up to 180° F. were maintained for seven hours, and no sign of vermin was subsequently found. Harned and Allen report similar experiments. In their case the room was heated to a temperature of 120° F. by steam radiators, the temperature being maintained for two days. Lower temperatures for longer periods were found reasonably effective. Ross describes similar experiments made in three rooms. The maximum temperatures attained in nine hours were respectively 162° F., 140° F., and 158° F., after which the rooms were allowed to cool gradually. All stages of insect life were killed. Experiments have also been made in America with superheated steam, as well as with heating the air of the rooms, and considerable success has been claimed. It would appear that experiments along these lines might well be tried out in this country.

(4) **Steam Disinfection.** While infested bedding may be treated with any one of the poisonous gases with success, this practice is to be discouraged because of the quantity of gas absorbed by such bedding and the subsequent difficulty of removing same after treatment.

For the disinfestation of verminous bedding, curtains, loose covers or even carpets, there is no real substitute for high-pressure steam, which is essentially safe and effective. As most local authorities maintain or have access to a steam disinfector, this type of treatment is almost always available.

Steam disinfectors are reliable, yield a speedy result, and supply a deep penetration of the bedding. In the design of a disinfecting station the main essential is the isolation of the "infected" and "disinfected" sides, no intercommunication being allowed save through the apparatus itself. The machine should be built into the dividing wall between the two compartments, a fixed glass panel being provided for observation purposes. The verminous articles, which arrive packed in canvas bags, should be passed into the machine from the "infected" side and should leave, after treatment, by the "disinfected" side. A laundry is often provided at a disinfecting station where washable articles can be washed and dried before being returned to their owners. A drying-room should also be provided, as, when large numbers of articles have to be treated, these may leave the machine in a damp condition. The usual form of drying-room is heated by means of steam pipes fixed in the form of racks, upon which the bedding is laid. Bathrooms should be provided for the staff complete with showers. Two vans should be used for the carriage of bedding, one for the verminous bedding and the other for the treated material. This requires the provision of two separate garages. The vans should preferably be painted in different colours, the psychological effect upon the owners of infested material being thereby considerable. A cleansing station for verminous persons should,

whenever possible, be provided adjoining the disinfector. Such a station usually consists of a waiting-room, a head-cleansing-room, and bathrooms with dressing-rooms attached. Clothing can be disinfected while the owner is undergoing treatment. Verminous persons should also enter by one door and leave by another to avoid contact.

The buildings should be effectively lighted, adequate roof lights being provided in addition to standard windows. The walls should be internally faced with glazed bricks or tiles, the angles between the floors and walls and ceilings and walls should be rounded off, while every precaution should be taken to facilitate cleansing.

The *Washington-Lyon* (Manlove, Alliot & Co.) high-pressure apparatus is well known and highly efficient. It consists of a hollow-jacketed metal chamber with a separate boiler. The articles to be treated are placed in a large wire cradle which can be run out of the chamber on rails. At each end is a heavy iron door which fastens by means of clamps on a rubber seating. When the chamber has been filled, the doors are closed and the steam, at a temperature of 240° to 250° F. and under a pressure of 20 lb. per square inch, is admitted to the hollow jacket to heat the interior surface of the chamber and so prevent condensation. When the walls have been sufficiently heated, a partial vacuum is produced inside the chamber by blowing a steam jet over a small orifice, which leads into the chamber. This vacuum assists the steam to penetrate the bedding. Steam under a pressure of 20 lb. per square inch is then injected into the chamber, this injection continuing for some twenty minutes, when the process is complete. To dry the articles, which will be somewhat damp after this

treatment, a partial vacuum is again produced, while a current of hot air is drawn through the chamber. A thermograph should be provided to show the temperatures reached during the process. Because of the high temperatures attained, all vermin and their eggs are quickly destroyed by this process, however deep-seated these may be.

(5) **Soap and Water.** Dr. Gunn, of the Glasgow Public Health Department, among others, has repeatedly stressed the importance of creating a higher standard of cleanliness in that section of the public usually associated with vermin, a liberal and continued use of soap and water being particularly advocated. This conception is nothing if not logical, and, whether or not insecticides are used, it should automatically be put into practice in every district.

While the psychological value of a strong smelling disinfectant or insecticide is apparent in many of the poorer areas, preventive measures, *i.e.*, cleanliness, should always be given prominence in any public health programme. Such cleanliness will do more to provide freedom from vermin than will any system of eradication carried out under conditions in which primary cleanliness does not exist. Unfortunately the average person interested in property often blames the occupiers for infestation, being neither careful in his investigations nor helpful in his criticisms. Occupiers should always be instructed, if necessary, in at least the rudiments of cleanliness. They should further be informed that vermin can, by constant effort, be eradicated, and that the appearance of such insects is a misfortune and does not necessarily imply a fault. Instructions should also be given as to the measures which should be adopted

to maintain dwelling-houses in a condition free from vermin.

The Glasgow system, if it may be so termed, makes use of strict cleanliness following fumigation with sulphur dioxide. Repeated visits and revisits are paid to verminous property by a staff of trained health visitors, and it is claimed that not only are verminous houses eventually cleared, but that vermin are not transferred in any large number to new houses from slum properties. This procedure depends upon the active and intelligent co-operation of the tenants themselves, and, if the work is properly organised and supervised, it will probably be effective. It should, however, be granted that such a scheme would be difficult to operate where the tenants are unsatisfactory. In such cases the eradication of vermin by means of soap and water alone would entail a long and laborious process.

CHAPTER IX

THE TECHNIQUE OF FUMIGATION

THE technique of fumigation can be conveniently divided into two sections :

I. FUMIGATION OF PREMISES
II. FUMIGATION OF FURNITURE

I. Fumigation of Premises. The actual methods by which dwelling-houses may be fumigated are of considerable importance, in view of the poisonous nature of most of the gases used. Different methods are required for each type of gaseous fumigant. These will be dealt with in the following order :—

(1) Hydrogen Cyanide.
(2) Orthodichlorbenzene.
(3) Heavy Naphtha.
(4) Sulphur Dioxide.
(5) Ethylene Oxide.

(1) HYDROGEN CYANIDE. The fumigation of premises with hydrogen cyanide presents a most complex problem by reason of the varying conditions which may exist in the different premises requiring treatment. This variation does not allow the treatment to be standardised in every case, and consequently different premises will require different methods of treatment. Before any fumigation with this gas is begun, certain essential points must be given detailed consideration. These are :—

(i) Can the gas be used with perfect safety ?
(ii) Does the type of house lend itself to fumigation with hydrogen cyanide ?
(iii) Is there *any* means of communication with various adjoining premises ?
(iv) Can efficient ventilation be carried out ?

There is a considerable weight of public health opinion against the use of hydrogen cyanide as a fumigant, but those who employ it regularly do not seem to mind the risk. In van fumigation, which will be dealt with later, the owners of the furniture are not open to danger, provided care is taken to ensure that the furnishings are entirely free of absorbed gas before further use. Danger in van fumigation only arises during the ventilation process. In houses, however, danger exists both for the operatives and for the occupiers of adjoining houses. Because of this constant risk, the staff responsible for the execution of the work should never be allowed to assume a casual outlook towards their duties. Operators and supervisors should always remember that fumigation with hydrogen cyanide must never become a purely mechanical operation. The poisonous properties of the gas necessitate the elimination of all mistakes, especially as such errors may well prove fatal. In short, the familiarity complex should at all costs be prevented.

It is essential that premises should be correctly measured in order that the proper quantity of fumigant may be applied and the desired concentration obtained.

The *procedure* of fumigation in all premises is carried out in three distinct stages :—

(*a*) Sealing.
(*b*) Fumigation proper.
(*c*) Ventilation.

(*a*) *Sealing*. All crevices and other means by which the gas might escape should be sealed, not only because of the danger arising from the use of such fumigants, but also to maintain as great a concentration of gas as possible in the rooms. While vermin are easily killed if the selected agent is speedy in action, insects quickly scent danger. The gas, whatever type may be used, must therefore be of adequate concentration. This concentration must also be maintained for a sufficient length of time. This can only be attained by efficient sealing. Every possible factor associated with the escape of gas must be surveyed prior to the commencement of fumigation, precautions being taken to ensure that no openings are overlooked.

The material used for this purpose should be as non-porous and non-absorbent as possible. Grease-proof paper may now be obtained in rolls of suitable width, and is essentially satisfactory. The sealing paper should be affixed with a good flour paste. The premises may be sealed either externally or internally. Opinions as to the relative value of these two methods varies. External sealing is at the mercy of the elements, and wind and rain may destroy the seals. If the building is constructed with cavity walls it is essential that the entire block of houses should be vacated, unless sealing is carried out internally. If this is not done, fatalities may occur through the gas travelling along the cavities into premises some distance away. On the other hand, if the sealing is carried out internally, the vermin may be present in the cavities and window and door casings and will remain untouched. Fire-grates, windows and doors should be heavily sealed. The front door should be sealed internally, the

operators leaving by the back entrance, which is sealed externally.

Two or more fireplaces often communicate with one flue, and gas may percolate, just as vermin may travel, *viâ* the cracks in the brickwork of the flue to adjoining houses. When dealing with windows it is advisable to seal and cover the glass with brown paper. The space which remains between the window opening and the glass provides useful insulation, particularly valuable in winter as a means of maintaining the temperature of the rooms. Darkness encourages the insects, particularly bed-bugs, to leave their hiding-places, a point of some practical importance. Chimneys should be sealed by means of rubber caps. If this is not possible, the pot should be removed and the opening sealed with slate, mortared down. All sealing operations should be thoroughly checked, an excellent plan being for the operators to check each other's work.

(*b*) *Fumigation Proper.* While hydrocyanic gas may be generated by any one of the methods described in Chapter VII (see pp. 117–123), it is now usual to use either Zyklon or Celophite Units for house fumigation, from the point of view of both safety and convenience. The following quantities will give the required concentration :—

Zyklon. 280 grams per 1,000 cubic feet. Minimum exposure, four hours. Maximum exposure, eight hours.

Celophite Units. 6 ounces per 1,000 cubic feet. This is equal to 1·5 volume per cent. for 1,000 cubic feet.

Experience has shown that the theoretical concentration is never reached in practice. While this is partly due to the difficulty experienced in rendering premises

completely gas-tight, absorption and adsorption of the gas by walls and floors, etc., accounts for some loss, while further loss occurs following condensation of the gas on walls, floors and ceilings if the temperature is not sufficiently high. The loss is to a certain extent compensated by the fixed cupboards, chimney breasts, and furniture (if any) left in the room. It should always be borne in mind that the greater the concentration, the greater the absorption, and, with this in mind, the dosage should always be reduced to a working minimum in order that subsequent ventilation will not be hampered by quantities of absorbed gas coming away slowly from the materials in the room. As the concentration in the immediate neighbourhood of evolving gas is considerable, the value of a dry form of gas which can be distributed over the entire floor area will be realised.

The optimum room temperature is 60° F. and over, even in winter, although success can be achieved at lower temperatures, and this temperature is best attained by the use of heating stoves. Primus stoves are admirable for this purpose, being both economical and efficient. There is no great harm in overheating rooms, but lack of sufficient heat will prevent efficient diffusion of the gas. Where there is a quantity of absorbent material present, or in situations where loss of concentration is likely to occur, the fumigant must be applied in shock doses. In all other instances it must be evenly distributed. Shock doses should always be given in roof spaces, because of leakages which occur through the slates or tiles. The material should be placed in heaps when roof spaces are to be treated. This allows the gas to be evolved slowly and continuously. Six to ten times the amount of fumigant

usually required for the space to be treated is normally used in such situations, this procedure allowing a continued renewal of a low concentration over a lengthy period. Where there is a quantity of absorbent material in the rooms to be treated the gas should be widely distributed and the doses reduced to the minimum consistent with efficiency. When the fumigant is properly distributed the gas is evolved rapidly.

The fumigation of bedding by means of hydrogen cyanide is to be discouraged, as the material will retain the gas for several days. Steam disinfection should always be relied upon to deal with infested bedding. It is, however, sometimes impossible for a variety of reasons to remove bedding for steam disinfection. In such cases hydrogen cyanide may have to be used, when the following precautions become necessary :—

(*a*) Mattresses should be placed on end to prevent excessive absorption.

(*b*) The bedding should be adequately warmed in a drying atmosphere after treatment and thoroughly shaken.

(*c*) The material should be retained at least two days before being returned to the owners. A thorough test should be carried out before this is done.

Box spring mattresses which cannot be disinfected by steam may be treated in this way.

(*c*) *Ventilation.* This is a most important process which should occupy at least twenty-four hours. Doors should first be opened and a short time allowed to elapse before the premises are entered, following which windows, doors and firegrate openings should be unsealed and opened. The upstairs rooms should be opened up first, followed by the ground-floor rooms. All advan-

tageously placed openings should be opened up to promote the passage of through currents of air. Windows should be opened one at a time, with intervening intervals. When all the windows are thrown open together for ventilation purposes and the windows of adjoining houses are open, the rush of gas which ensues may possibly contaminate the rooms of such adjoining houses. The windows of adjoining premises should preferably be kept closed while the houses under treatment are cleared of gas.

The residues are removed for destruction as soon as the property is entered. When the residue from the roof is removed, a match should be applied to the material in order to burn off the gas contained before final disposal. After ventilation has proceeded for several hours, the rooms should be closed and left for the night. It will generally be found that additional quantities of gas are present on the following day, such additions having been emitted from the absorbent surfaces in the room. Further ventilation will then be required. Chemical tests should be applied to the walls, floors, floor and roof and dead spaces, and to the atmosphere of the different rooms; while any bedding or upholstery left in the rooms should be carefully tested. It must again be emphasised here that it is *not* advisable to treat bedding with hydrogen cyanide. Upholstery should be tested with the utmost care and should not be passed as safe until all blue colouration has disappeared and the test paper laid *between* such goods after thorough beating shows a negative result. Particular attention should be paid to cupboards, drawers, and clothing. After all the tests have been made and the final test is satisfactory, the premises may be reoccupied and the essential

supply services, such as gas, water and electricity, reinstated. Similar chemical tests should be made in adjoining property. Ventilation is sometimes difficult on damp, humid, windless days, as dispersion of the gas then becomes a problem.

The *chemical tests* which may be used following fumigation with hydrogen cyanide are as follows:

(*a*) *Guignard's Test.* Picric acid solution and sodium carbonate solution are mixed to form sodium picrate. Strips of paper are impregnated with this solution and dried. If the colour changes from yellow to orange and finally to copper colour when these are exposed to the atmosphere or other surfaces, the atmosphere is polluted.

(*b*) *Schoenbein and Pagenstecher Test.* Guaiacum resin in alcohol and copper sulphate solution in alcohol are mixed. The presence of hydrogen cyanide is shown by the colourless paper changing to pale blue and finally to deep blue.

(*c*) *Thiéry's Test.* Phenolphthalein and copper sulphate solution are mixed, after which caustic soda is added. The presence of hydrogen cyanide is indicated by the colour change from colourless to deep pink.

(*d*) *Methyl Orange Test.* This may be used to indicate the presence of hydrogen cyanide, but is not to be recommended for this purpose.

(*e*) *Sievert and Hermsdorff Test.* This is the standard test for the presence of hydrogen cyanide. Copper acetate solution and benzedene acetate solution are mixed immediately prior to testing, as the latter solution rapidly deteriorates. The test solution is obtained by dissolving 1 gram of benzedene acetate and 3 grams copper acetate, each in 1 litre of distilled water. Equal parts of the solutions are mixed, the strips of paper being dipped as required into the mixture. A dark brown bottle should be used for the storage of the benzedene acetate solution to prevent deterioration.

Testing sets which comfortably fit the pocket may be obtained, containing :—

(i) Two light-coloured glass tubes with metal caps containing a solution of copper acetate.

(ii) Two brown glass tubes containing a solution of benzedene acetate.

(iii) One tube with a rubber stopper for use as a mixing vessel.

(iv) One small stoppered tube containing calcium cyanide which is used as a control.

(v) Two tubes with cork stoppers for holding moistened paper strips.

(vi) Two small plain glass tubes containing sufficient chemical to obtain ½ litre of copper acetate solution.

(vii) Two small brown glass tubes containing sufficient chemical to obtain ½ litre of benzedene acetate solution.

(viii) A colour specimen.

(ix) Strips of test paper together with directions for use of the outfit.

The depth of colour varies with the variety of test paper used. Recommended papers are Whatman's No. 3 or Green's No. 500. The presence of hydrogen cyanide is shown by the change in the colour of the paper from colourless to deep blue, according to the quantity of gas present. The test paper should be exposed, when any variation in the blue colouration will be readily appreciated.

The following indications show the strength of the hydrogen cyanide present :—

(i) Immediate blue-black colour	1	part per 1,000
(ii) Immediate blue . . .	0·1–0·2	,, ,,
(iii) Medium blue in five seconds with change to dark blue in forty seconds.	0·01–0·02	,, ,,

(iv) Commences to change at twenty-five seconds. Pale blue colour appears at one minute with a decided blue colour in two minutes.	0·001 part per 1,000

If, in spaces devoid of retentive materials, a series of tests shows no appreciable blue colour on paper in thirty seconds or over, the atmosphere is safe to breathe.

Special precautions should be taken with *adjoining premises* during fumigation processes. When the fumigation is in progress the bedding in adjoining premises should be moved as far distant from the party wall of the house being treated as possible. *After* fumigation (including subsequent ventilation) has been completed, the occupiers of adjoining property should be warned to keep their windows open day and night, while thorough tests of adjoining roof spaces should be made. Instructions to tenants should always be given in writing, copies being kept to prevent subsequent possible misunderstandings.

During the fumigation of houses with hydrogen cyanide certain *precautions* must be taken. These may briefly be stated as follows :—

(i) Operations should not be commenced unless the operators are properly trained and thoroughly conversant with their work. At least two operators are required.

(ii) The rooms to be fumigated should be correctly measured in order that the correct quantity of the fumigant may be applied. This is essential.

(iii) All occupied premises, above, below and laterally adjacent, must be vacated during fumigation and ventilation. These should be inspected by the supervisor in charge of operations.

(iv) Care must be taken to ensure that the party walls

in the house to be treated and in adjoining houses are carried up to the roof, and that there are no sub-floor ventilators communicating with adjoining property.

(v) All foodstuffs and domestic animals must be removed from the premises, the water supply must be turned off at the main and all cisterns emptied, while electricity and gas supplies should be turned off at their respective meters.

(vi) The police and fire brigade should be notified.

(vii) All exits must be sealed.

(viii) The fumigant must be arranged at convenient positions.

(ix) Before any gas is discharged, masks must be worn. Warning notices must be posted on the front and rear doors of the property similar in type to that shown below. In addition, a watchman should be posted.

Borough of . . .
DANGER
Premises under Poison Gas
DO NOT ENTER

Warning signs should be illuminated at night.

(x) When fumigation work is carried out in public thoroughfares, people must not be allowed to congregate in front of a house under gas.

(xi) No fumigation should be carried out unless a first-aid set with drugs for the use of a medical practitioner together with a gas resuscitation apparatus are provided.

(xii) Adjoining houses should be tested for leakages immediately after fumigation has begun.

(xiii) No person should be allowed to enter a house under

gas, or adjoining houses, alone. Operators should work in couples. Gas masks should always be worn both when distributing the gas and when opening up for ventilation purposes.

(xiv) If a fire should break out when a house is under gas, the rooms should be ventilated at points furthest from the fire.

(xv) Carpets which have been left in rooms should be removed into the open air and thoroughly beaten after fumigation has been completed.

(xvi) Windows in sleeping-rooms should be fixed in an open position at night after the house has been certified as fit for use again and should remain so for at least twenty-four hours.

(2) ORTHODICHLORBENZENE. Orthodichlorbenzene as described on p. 127, is not a gas, but is a liquid which vaporises after spraying. It must always be remembered that this material should only be employed in empty houses, being particularly valuable for disinfestation of slim property prior to demolition. The rooms to be treated should first be measured, in order to ensure a reasonably accurate dosage, while, if the premises to be dealt with are warmed prior to the commencement of operations, more satisfactory penetration will result. In warm weather preheating may be dispensed with, but only when really high temperatures are attained. In slum properties difficulty may often be experienced in heating such premises. The premises must be securely sealed externally wherever possible. Any fires should be carefully raked out. The mixture may be applied by means of a large pressure spray, preferably of the pencil variety, capable of working at a pressure of 60–75 lb. per square inch. An electrically-driven atomiser may also be used with advantage. If a manual or foot pump

is used, the machine should be repumped to the original pressure when half the liquid has been ejected. One gallon of the liquid is used for every 1,000 cubic feet, being sprayed on walls, floors, ceilings and all woodwork. It is advisable that all woodwork should be eased and cracks in the plasterwork thoroughly saturated. In dealing with lath and plaster partitions, several small apertures should be bored, the nozzle of the spray being inserted and a thorough application given.

Within a few minutes of the commencement of spraying, a heavy concentration will be attained. For this reason the person carrying out the work must wear a respirator fitted with a suitable filter. When treatment has been completed, the door must be sealed and the premises left for eighteen to twenty-four hours. A similar period is required for ventilation. When the premises are opened up, a respirator is again necessary. Where ventilation is exceptionally good, the rooms may be clear of gas on the evening of the day upon which they were unsealed. A fire in the room, together with open windows, will disperse the fumes within a short space of time, but in all cases it is advisable to leave the windows open until the following day. The odour will linger for several days.

(3) Heavy Naphtha. Probably the most important point to remember when treating rooms with heavy naphtha is that preheating is always necessary if the internal temperature is below 60° F., quite independent of the temperature out of doors. Further, another point to note is the fact that the higher the temperature attained the higher will be the concentration. Primus stoves or electrical heaters may be used for this purpose.

In empty houses provided with electricity, electric heaters may be left working overnight, but if the premises are occupied, or Primus stoves are employed, preheating must be begun early in the morning. Sufficient time should be given for the heating apparatus to warm the surfaces of the walls and ceilings thoroughly. While it is not essential that woodwork should be removed, it is advisable to ease off skirtings and mouldings Windows should be sealed with stout brown paper, preferably on the exterior, the entire surface of the glass being covered in order to darken the room. This procedure is said to encourage the insects to emerge from their hiding places. Rooms may be darkened internally by hanging a blanket over each window. Firegrates should be thoroughly sealed. If the metal parts of the grates are finished with japanned black, these should be covered with mutton cloth to prevent any interaction between the japan and the naphtha. The furniture should be removed to the middle of the room and covered lightly with a dust-sheet or blanket. Light cotton diffusion screens should also be hung over the windows, along the walls and across the room. These "diffusion screens" are thoroughly soaked with naphtha during the spraying process and assist in building up an exceedingly high concentration of gas in the room. They retain a charge of naphtha for twenty-four hours and one standard screen, 16 feet by 3 feet, will absorb 1 pint of naphtha. It is advisable to remove linoleum from the rooms, particularly the cheaper variety. If this is not done, interaction may occur between the paint and the naphtha, resulting in damage to the article and a subsequent claim for compensation.

Certain precautions, which have already received

brief mention, must be taken when heavy naphtha is used. Care should be taken to ensure that no damage is done in using the liquid. Paint is often readily affected, as the cheaper varieties usually contain naphtha as a thinner. In such cases the two naphthas combine and the paint runs. A similar difficulty may be experienced with japanned articles. All such surfaces should be protected with mutton cloth. Poor quality linoleum, of the painted canvas variety, has already been mentioned. If linoleum of this type is not removed from the room it should be covered with crinkled paper or blankets.

When sealing and other preparations have been completed the heating apparatus is removed and the premises are ready for spraying.

The roof space is first thoroughly sprayed to give a high concentration, blankets being used instead of screens. (Note.—When a house has been warmed it is advisable to spray the roof space before the heating stoves are removed.) The rooms are then sprayed, working from the top floor downwards, and spots likely to be heavily infested are given concentrated doses. Two gallons of heavy naphtha is required for each 1,000 cubit feet of room space. It is again necessary to stress the fact that rooms should be carefully measured in order to determine the exact quantity of liquid required to give the desired concentration. Screens placed in the room are saturated as previously described, and, when spraying is complete, the doors are sealed. The following points should be emphasised in spraying with this liquid :—

(i) The atmosphere should be thoroughly saturated.
(ii) Heavy naphtha is highly inflammable and should never be used in the presence of a naked light.

Fires should always have been drawn previous to the commencement of spraying, and smoking should be prohibited during operations and the gas turned off at the meter.

(iii) Respirators fitted with suitable filters should be worn during operations, owing to the heavy con centrations involved.

(iv) A suitable concentration must be maintained.

(v) The higher the temperature within limits, the more successful will the operation be. Fumigation should not be commenced until the temperature of the rooms is at least 70° F. Temperatures of 80° to 90° F. may be used with success.

Spraying may be carried out by means of any good type of pressure spray, giving a pressure of 60–80 lb. per square inch. The foot type will be found most useful for this purposes. The rooms are sealed for eighteen to twenty-four hours, after which they are ventilated for six to eight hours. In practice it is often found that they may be entered after ventilation has been in progress for fifteen to thirty minutes. Respirators should, of course, be worn when opening up. There is no tendency for a concentration of the vapour to "build up" if the doors and windows are closed again after ventilation for several hours. Diffusion screens which have remained in the rooms should be thoroughly aired in order to remove any remaining naphtha.

To achieve success in the use of heavy naphtha the following essentials should always be borne in mind :—

(i) As great a concentration as possible should be given.

(ii) Provide a high initial temperature.

(iii) Remember that high concentrations will cause con siderable discomfort if respirators are not worn.

(4) Sulphur Dioxide. Fumigation with sulphur dioxide, if it is to be even fairly satisfactory, requires as

much care and forethought as is necessary in the application of other gases, although in the past haphazard methods have robbed this material of much of its efficiency. Sealing of rooms is again important. All doors and windows must be sealed with non-absorbent materials. Flues should be stuffed with sacks, while it is advisable to ease skirtings, architraves and window-boards. All metal surfaces should be greased to prevent tarnishing, and marble slabs, so often found in the older type of bedroom suite, should be covered. Fine-textured materials should be removed from the room and sprayed with liquid insecticide. Bedding should be removed and treated with steam. Pictures should also receive separate treatment. The walls and ceilings should be sprayed with water, since moisture combines with the sulphur dioxide to form sulphurous acid. This, however, exerts a considerable corrosive effect. The roof space cannot be readily treated with sulphur dioxide unless a tarpaulin is fixed over the roof. It is advisable to spray this position with a liquid insecticide, the upper sides of the ceilings, the ceiling joists, the brick-work of the chimneys and the party walls being treated in a similar manner.

When sulphur dioxide is used as a fumigant a quick and sudden concentration is essential. For this reason a mixture of 95 per cent. flowers of sulphur and 5 per cent. potassium nitrate should be used, 6–8 lb. per 1,000 cubic feet being required. If the liquid form of gas known as sulphume is used, 70 ounces per 1,000 cubic feet will be adequate. The period of exposure need not be more than six hours. If destruction of vermin has not been completed within that period it is unlikely to occur with prolonged exposure. The

powdered mixture is placed in small metal containers, with wicks fashioned from grease-proof paper. These containers should be placed in metal trays arranged at different levels, to assist diffusion of the gas. Each tray should contain sufficient water to prevent any risk of fire. In dealing with property undergoing repair, two applications should be given. The first application should be supplied before any work is done to the house. After woodwork and paper have been removed, a second dosage should be applied. If possible, the entire house should be treated at one operation. If the rooms are treated in rotation the vermin may travel from room to room in order to escape the gas. When only part of a house is treated it is not necessary to vacate the premises, the tenants being allowed to remain in the unaffected portion, but this procedure naturally affects the efficiency of the work. When rooms are under gas, a notice in the form set out below should be posted on the door of the room or premises :—

> Borough of . . .
>
> Room under Fumigation
>
> BEWARE OF SULPHUR DIOXIDE
>
> This room must remain closed until . . .

After removal from the premises, pictures should be placed in a large zinc-lined box and treated with a 12-ounce canister of Sulphume. The period of exposure

necessary is twelve hours. When this period has expired, the pictures should be taken to pieces, brushed with a wire brush and thoroughly cleaned.

The room should be ventilated after the requisite period of exposure by breaking the seals, throwing open all windows and doors, and removing the seal from the firegrate. Respirators fitted with the appropriate filters must be worn during this operation. Ventilation should be carried on for at least six hours, while longer periods, up to twelve hours, may be necessary, according to weather conditions. Users of sulphur dioxide claim a fair efficiency for this method, but a further dosage at the end of ten days is advised unless all paper and woodwork is removed and a good liquid insecticide employed prior to fumigation.

(6) Ethylene Oxide. Ethylene oxide is generally used in this country in the proprietary form of Etox, which is a 9 to 1 mixture of ethylene oxide and carbon dioxide. While its efficiency is not equal to that of hydrogen cyanide, it is much less poisonous to human beings. This gas is, however, rarely used for house fumigation because of its high cost, but is successfully employed for the fumigation of single rooms and private flats. Exact determination of the cubic capacity of the room or rooms to be treated is again necessary, with one important difference. *External* measurements should always be calculated because of the great powers of penetration and absorption exhibited by this gas. Fires in rooms must be extinguished since Etox is very inflammable and explosive, although the admixture of carbon dioxide reduces the risk of fire to a considerable extent. Smoking must also be strictly forbidden. Cupboards and drawers should be opened, beds dismantled,

and pictures removed from the walls. For each 1,000 cubic feet of space, 1,500 grams of ETOX are required, the exposure period being twenty-four hours. The gas is distributed direct from a cylinder placed either inside or outside the room. If distributed from the exterior, one end of a flexible copper tube is fixed to the cylinder, after the room has been sealed, while the free end, containing a spray nozzle, is inserted through the keyhole. Care must always be taken to ensure that the gas spray points towards the ceiling and it does not come into contact with polished or varnished furniture or woodwork. Objects in the immediate vicinity of a discharging cylinder of ethylene oxide must be covered with paper or cloths. The valve of the cylinder must be opened to its widest extent. This produces a very fine spray, preventing the formation of liquid drops. A respirator fitted with the appropriate filter should always be worn when handling this gas, and when entering premises for ventilation purposes after fumigation is complete. ETOX is extremely toxic to human beings and animals, and this point should always be remembered.

II. Fumigation of Furniture. The fumigation of furniture may be carried out in either of two ways :—

(*a*) Van fumigation.
(*b*) Van chamber system.

(*a*) VAN FUMIGATION. The essence of van fumigation lies in the building up of a toxic concentration of the gas used for the destruction of vermin in household effects inside the van. The success of the method depends upon :—

(i) The nature and construction of the van.
(ii) The concentration of the gas.

(iii) The temperature attained by heating.
(iv) The period during which the contents of the van are exposed to the gas. In this connection, sufficient time must be allowed for diffusion of the gas and also for absorption of the fumigant by the contents, particularly wooden articles and upholstered furniture.

The employment of vans for the disinfestation of household effects affords many advantages, as follows :—

(i) Operation is simple.
(ii) Once the cubic capacity has been ascertained the dosage is constant.
(iii) The normal concentration is always known.
(iv) The van can be placed at any suitable point.
(v) The operation of fumigation can be readily systematised.
(vi) All the furniture can be removed from a house, treated, and finally removed to a new house without unloading.
(vii) A well-constructed van is easily rendered gas-tight.
(viii) A strong concentration of gas may be used, thus reducing the period of exposure.

Several types of vans are used for this purpose, the simplest form being the ordinary pantechnicon converted to suit the requirements of the process. In many districts special types are used, the design varying according to the individual ideas of those responsible for the work.

The use of ordinary pantechnicons which were never designed for this purpose is not to be recommended, particularly if the vans have seen much service. In many cases the joints will be open, rendering the containers anything but air-tight. To make good this defect, much sealing will be required. Open joints will most often be found behind the driver's seat. In

addition to these defects, such vans are difficult to ventilate, since they possess no front openings or fans to assist in a speedy and thorough diffusion of air. If a van of this type must be used for any reason, such as that of economy, all open joints should be properly sealed. Heating, of course, is essential, and may be provided, if an electric supply is readily available, by means of electric radiators. If electric power is used for heating purposes, closure of the doors is often difficult by reason of the cables leading to the radiators. Ventilation requires assistance by the provision of an electric fan, for which power must be available. As the door is usually placed in the rear, ventilation may also be assisted by placing the van in such a position that any wind drives across the door opening.

A special type of van has been designed for this work by the Imperial Chemical Industries Ltd., such vans having been used with considerable success at Kensington and Leeds. This type of van may, however, often cause considerable embarrassment to the tenants of houses outside which it waits as it so obviously looks what it really is. The vans and their stations, which should be set up at a distance from any inhabited area, are, of course, expensive to provide, but are eminently suitable for their purpose. They have been designed with the following essentials in view :—

(i) Sound construction.
(ii) Suitable means of introducing the gas.
(iii) Tight-fitting doors.
(iv) Efficient means of ventilation.
(v) Suitable means of heating

These vans are a modification of the type used by the various railway companies for their door-to-door

transport and are of all-welded steel construction. They are provided with a stout sliding door at one side, which can be efficiently sealed, closure being provided by means of screw clamps. The van is capable of withstanding a pressure of three atmospheres. The measurements are approximately 14 feet by 6 feet 6 inches by 6 feet 8 inches, and from the chassis, each van runs on small wheels on to rails fixed at a suitable working height. Two or more of these vans may be housed side by side, protected from the elements by means of a Dutch barn. Gas-tight electrical tubular heaters are provided on all sides of the ban. The tubes are six in number and reach to a height of 2 feet 6 inches from the floor of the van, being protected from damage by means of a stout steel mesh. The electrical connections to the heaters are fixed in a recess situated at one end of the van. This recess, which is accessible from the exterior of the van, contains, in addition to the electrical connections, the vaporiser in which liquid cyanide is boiled, and also an outlet connection to an exhaust fan, the latter connection also being made from the exterior. This fan exhausts the air at the rate of 1,000 cubic feet per minute. The exhaust pipe is carried from the recess, up to the ceiling of the van, and round two sides to the corner diagonally opposite. The electrically heated vaporiser, which is in effect an electric kettle, is fitted at floor level. To ensure an efficient concentration in this size of van, 8 ounces of liquid hydrogen cyanide are required. This is poured into the vaporiser and boiled, the gas given off being diffused throughout the van.

The procedure of fumigation is briefly as follows. When the loaded van arrives at the disinfestation station, the bedding is removed for steam disinfection.

the van is then run off its chassis on to the rails and the door closed, the electrical heaters are connected up and switched on, and preheating is commenced. Heating usually occupies some thirty minutes. The exhaust outlet should be connected to the exhaust fan during the heating period, and should be tested, after which the outlet is closed. When the temperature has reached a sufficiently high level, the requisite quantity of liquid hydrogen cyanide is poured into the vaporiser. The current is then switched on, and the liquid becomes vaporised. The liquid evaporates in three to five minutes in summer and ten to fifteen minutes in winter, after which the current to the vaporiser is switched off automatically. It should be noted that the heaters may be switched off in summer immediately before the introduction of the gas, provided the external air temperature is high. The van is allowed to remain under gas for two hours. At the expiration of this period the outlet valve is opened, the exhaust fan set in motion, and the gas sucked out and discharged by means of a 30-foot chimney into the open air. The dangerous concentration of gas in the van can then be cleared before the door is opened. The process of exhaustion is carried on for two to three hours, after which the door of the van is opened and the contents allowed to air naturally for some time.

Tests should be made for the presence of hydrogen cyanide on the surfaces of all furniture, particularly upholstery. Even after these tests are satisfactory, upholstery and furniture should preferably be retained for twenty-four hours before being returned to the owner, all upholstery being periodically beaten to drive off any absorbed gas. The process can, however, be

cut down to six to eight hours from collection to return, although a great deal depends upon the atmospheric conditions prevailing on the day during which the work is carried on. The factors which must be taken into consideration when ventilating a van are :—

(i) Natural ventilation.
(ii) Humidity.
(iii) Wind velocity.

A simpler type of van may be used if desired, designed upon the lines of a small pantechnicon. This is constructed of match-boarding, with a tongued and grooved lining, and a floor on ash frames with oak bearers. All the external joints should be filled, and the exterior well painted. The usual size is 750 cubic feet capacity. A Dutch barn should be provided under which the vans may stand when fumigation is in progress. Such erections possess the following advantages :—

(i) The work can be carried out under cover, which means that upholstery can be safely and adequately beaten and aired.
(ii) Protection from the weather is afforded on all occasions.
(iii) There is no chance of gas pockets forming, since a good through current of air is provided.

A fan is provided at the front of the van to assist ventilation, an exhaust chimney being therefore unnecessary. The van is wired with both heating and power points. This is so arranged that either the heating apparatus or the exhaust fan can be put into operation while the van is under gas. In addition, an internal light is provided. A van of this type, similar to those in use

in the Metropolitan Borough of Woolwich, costs approximately £150 more than a pantechnicon of similar size. The fan, which is fitted over the driver's cab, deserves special mention. The opening is provided with a flap which seals it off from the external air, while between this flap and the fan a diaphragm is fitted. Both the flap and diaphragm are sealed while the van is under gas. After fumigation has been completed, these seals are broken and the fan is put into operation. One, two, or even three portable electric radiators may be used for heating purposes, a minimum temperature of 70° F. being attained.

The van is allowed to remain under gas for four hours. In this type of van liquid hydrogen cyanide is not used, a prepared form, such as Zyklon, being scattered over a sheet of brown paper placed on the floor of the van before the doors have been closed. Approximately 280 grams of Zyklon are required for 1000 cubic feet. If desired, the gas may be applied from a cylinder under pressure, while Celophite units can also be safely employed.

Van fumigation is, in many ways, the simplest and most efficient method to adopt, since a regular system of operation can be followed out. In dealing with vans it should always be remembered that wood absorbs considerable quantities of hydrogen cyanide. When vans are constructed of wood or possess wooden floors, such material should be painted to prevent absorption. If this is not done, the dosage will have to be considerably increased and subsequent desorption may be dangerous.

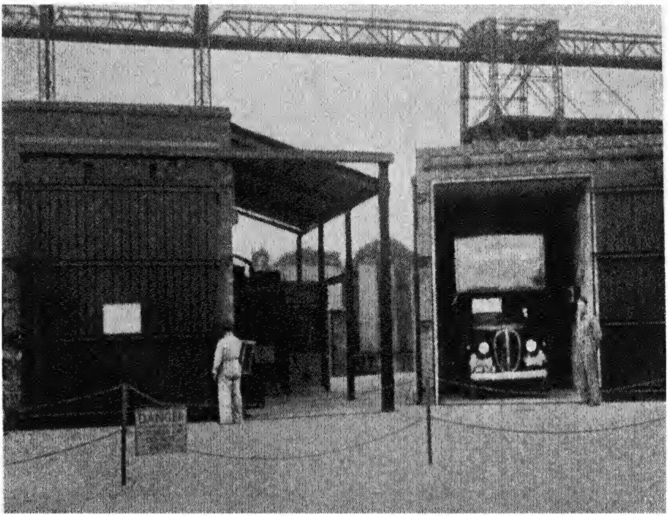
(*b*) VAN CHAMBER SYSTEM. This method, as carried out in the Metropolitan Boroughs of Hackney, Stepney

and Islington, Bolton, Preston and Wolverhampton, is eminently satisfactory, the advantages to be derived from its use outweighing any disadvantages which it may possess. While vans and containers are really fumigation chambers, the latter term is confined to permanent brick structures. The advantages obtained from the use of such a chamber are :—

(i) Any van, however imperfect or incapable of being sealed, can be treated together with its contents.
(ii) The temperature can be maintained.
(iii) The operators are not exposed to hydrocyanic gas, all operations being carried out outside the chamber.
(iv) Complete privacy is assured to the owner of the furniture, since private vans are employed for removal purposes.

Against these advantages may be set off the cost of erecting and equipping the chamber, the lack of mobility and an exceptionally large chamber to take a large pantechnicon with wastage of material. The chamber should be constructed of 14-inch brickwork set in cement, and rendered internally with cement and sand, the internal measurements being 26 feet long by 10 feet wide by 14 feet high. The internal surfaces should be given a thin coating of distemper, renewable annually. This prevents condensation and absorption of gas. The cubic capacity is approximately 3,600 cubic feet, giving a chamber sufficient in size to take the largest furniture vans. The floor should be of concrete and is given a slight slope towards the door, so that vans can run out, if desired, under their own weight. The door is approximately 14 feet by 11 feet and should be strengthened with channel irons. It slides on an overhead track, from which it is hung on swivel hinges. The door is sealed on

to a rubber gasket with screw clamps, and is fitted above and below with screw wedges. Heating is provided by means of two steam-heated radiators, a hot air panel being also fixed along one side of the chamber. At the posterior end of the chamber, in one corner, a



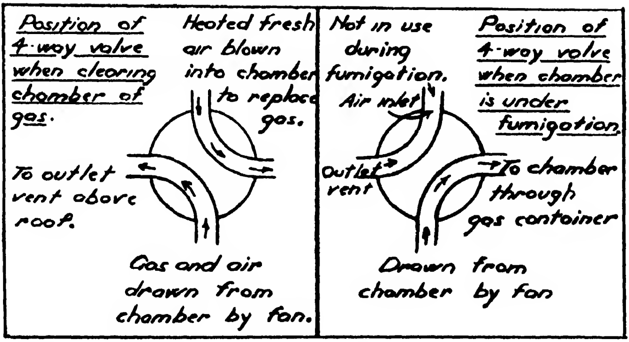
By courtesy of Dr. E. H. Dart, M.O.H., Metropolitan Borough of Hackney.

FIG. 20. Van chambers.

perforated gauze shelf is fixed over a radiator. Above this is a tin cutter, patented for opening tins of Zyklon, which form of hydrogen cyanide is used for fumigation purposes. A tin of Zyklon is loaded into its holder, and the cutter is adjusted so that it touches but does not puncture the tin. A few turns on the handle, which is operated from the exterior of the chamber, cuts out the

end of the tin. When the winding is reversed, the end is withdrawn, the tin swivels, and the Zyklon falls on to the zinc tray. The tin cutter is provided with various blades for use with different sizes of tins. An observation window is fixed on the side of the chamber opposite the tin cutter, so that the operation of cutting the can and the fall of the Zyklon can be observed. Another window is provided at the opposite end of the chamber over the hot air panel. On the side of the building opposite to the radiators, two 4-inch air inlets, three test pipes and a temperature recorder are provided. A hot air fan is provided near the hot air panel, while three hot air inlets are also included. From the end wall opposite the door, a 6-inch flexible exhaust pipe is fixed. This leads out of the chamber, up the back of the building, to a point some 5 or 6 feet above the highest point of the roof. A flap valve secured with wing nuts and capable of being raised by means of a chain effectively seals the opening when the chamber is in use. The exhaust fan is approximately 12 inches in diameter. Electric fans may be fixed at various points to assist in diffusing the gas. Some form of suction apparatus should be provided over the perforated tray containing the Zyklon, to carry a quantity of the gas direct into the van by means of a flexible pipe which is laid on the floor of the open van. This helps to provide a high concentration of gas amongst the furniture in the van. A similar apparatus may be connected through the window if one is provided at the rear of the driver's seat to further assist diffusion.

A lean-to shelter should be built along one side of the chamber. In busy times, a van may be backed under this shelter, while the contents are aired. In addition,



Apparatus in Use

In Apparatus Room.	Apparatus in Chamber
Fan - 4 H.P. - 15-16 changes per hour.	Conduit (Plymax ducts - 12"x6" at sides, 12"x12" at end
Gas container.	Iron bend (Duct to fan) 9" diam.
Four way valve.	Two 1½" connections for perforated pipes laid in van.
Outlet vent - 4" iron.	Thermometer giving external reading.
Air inlet - 4" iron.	Steam heated radiators
Steam heated radiator & hot air box.	Three 6" air inlets fitted with drain plugs.
Electric lights & fan control.	
Cyanide store (ventilated).	

Capacity of Chamber.

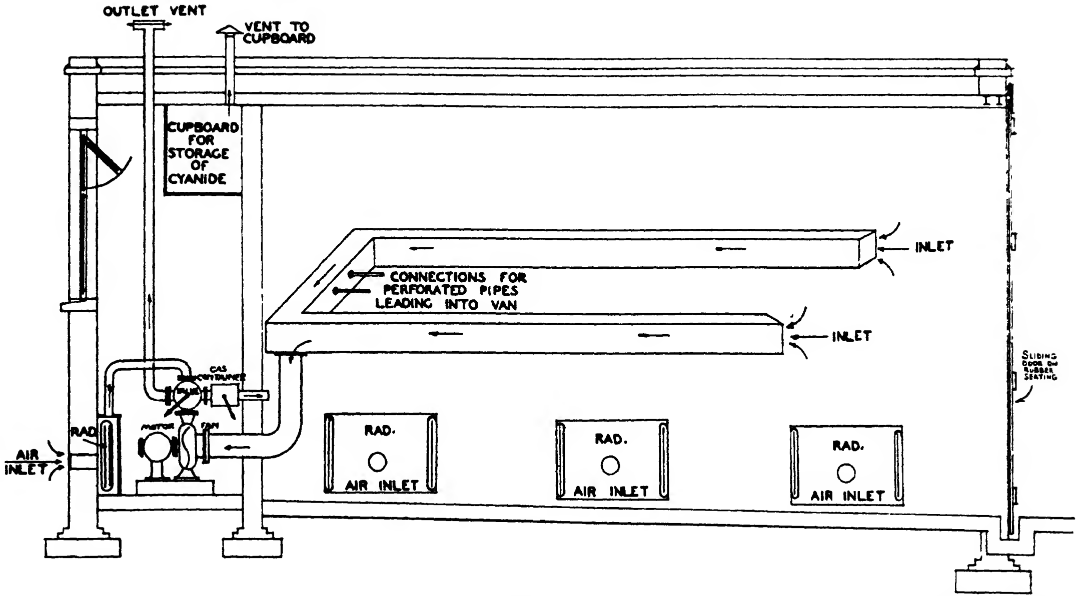
Length ·	25'·10½"	This will enable the large type of van to be put in, containing contents of 1-3 houses
Height ·	13'6" – 14'·0"	
Width ·	10' – 6"	
Cubic capacity ·	3736°	

Capacity of Apparatus Room

Length	· 10'-6"
Height	· 13'-6"
Width	· 5'-6"

By courtesy of Dr. E. H. Dart, M.O.H., Metropolitan Borough of Hackney.

FIG 21B. Data *re* fumigation chamber.



By courtesy of Dr. E. H. Dart, M O.H., Metropolitan Borough Council of Hackney

FIG 21A. Fumigation chamber.

such an erection provides shelter for the operators and the necessary electrical switchgear.

The concentration of gas in the chamber is less than 1 per cent., being approximately 0·8 per cent ; 357 grams of Zyklon are used for each 1,000 cubic feet.

The procedure of fumigating van and furniture is as follows :—

(i) The heat is turned on in the chamber sometime prior to the arrival of the van, in order to raise the temperature adequately.

(ii) The tin of Zyklon is inserted in the cutting apparatus. The apparatus should be well oiled, and the lid of the canister must not be pierced.

(iii) The van is backed into the chamber, after which the 6-inch exhaust pipe is inserted as far into the interior as possible.

(iv) The door of the chamber is closed and clamped tight, the two large air inlets also being closed.

(v) The hot air inlet is opened and the hot air fans switched on for ten minutes.

(vi) The flap of the exhaust valve is closed and screwed down.

(vii) The hot air inlet is closed.

(viii) The chamber is inspected to ensure that all openings are sealed. The canister is opened, one operator to see that the contents fall out as the container is inverted.

(ix) Five minutes later the hot air fans are switched on for one minute to assist in diffusing the gas. This process should be repeated at half-hourly intervals.

(x) The van is allowed to remain under gas for two hours. The exhaust outlet is then opened and the exhaust fan switched on.

(xi) The air inlet fan is switched on and the air inlets are opened.

(xii) Tests are made for gas through the test pipes at the side of the chamber. The door is not opened until

the tests show that the chamber is practically free from gas. Ventilation usually occupies one hour.

(xiii) The chamber is tested for gas on entering. If there is any sign of gas, the air inlets are closed, the fans left running, while the door is allowed to remain open until the gas has been cleared.

(xiv) The contents of the van are tested for gas, the driver's cab also being tested. Driver's cushions are removed and aired.

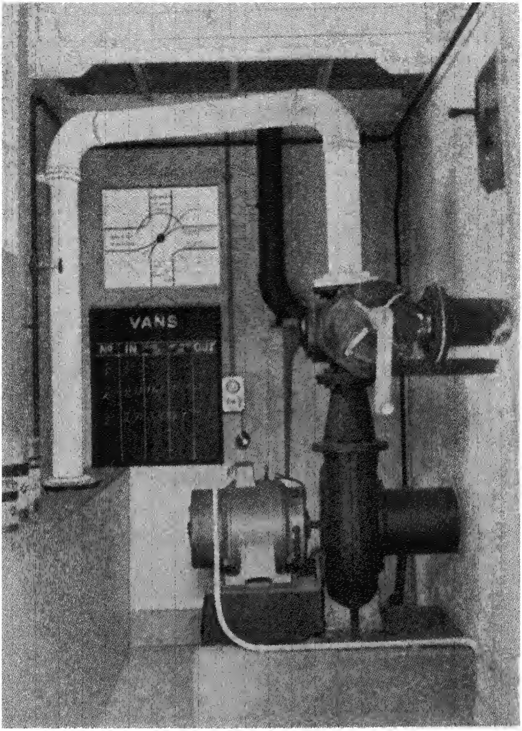
A small chamber may be built, operating on similar lines to that used for van fumigation. This can be used for treating small quantities of furniture, books, blankets, etc.

The fumigation chamber at Hackney has proved so successful that the Council have had yet a further chamber built. This new chamber is very similar in construction and design to the one already described, but its efficiency has been considerably improved by the fitting of a circulatory system for gassing and ventilation.

By passing a current of air from the chamber and through the Zyklon tin and circulating this gas/air mixture through the contents of the chamber, it is possible to evolve and to distribute the fumigant in the shortest period of time.

Rapid and efficient distribution of the gas is of greatest importance in fumigation technique, as this ensures that a minimum quantity of fumigant toxic to the insect pest is used without allowing unnecessarily high concentrations to form in furniture, etc., necessitating long periods of ventilation.

The apparatus consists of circulatory pipes and exhaust pipes, which are connected respectively to a



By courtesy of ***Dr. E. H. Dart, M.O.H., Metropolitan Borough of Hackney.***

FIG. 22. Circulating apparatus for van chamber.

four-way cock, a Zyklon generator, and fan and motor. The operation of the chamber is simple :—

(i) The loaded van is run into the chamber and the doors clamped tightly.

(ii) The Zyklon generator is opened and a Zyklon tin containing 1 kilogram of available hydrogen cyanide is placed inside it and the generator closed. This

operation is simple and may be likened to placing a cartridge in the breach of a gun.

(iii) The four-way cock is then given a half-turn to such a position as to allow circulation.

(iv) The fan, which is capable of giving a predetermined number of air changes per hour, is then switched on.

(v) The handle of the Zyklon generator is rotated for several revolutions in both directions. This has the effect of perforating the Zyklon tin at both ends and allows air to be drawn from the chamber by the fan, passed through the Zyklon tin and back into the chamber. After about twenty to thirty minutes the fan may be switched off and the van left in the now equally distributed gas/air mixture for a further hour or so.

(vi) To ventilate the chamber another turn is given to the four-way cock so as to allow fresh air to be drawn in right through the contents of the van and discharged from the exhaust pipe to the atmosphere. During this ventilation period tests may be taken of the atmosphere in the chamber with a suitable recognised chemical test.

Certain points regarding the fumigation of furniture require special mention. In the first place, the householder should receive notice of the time of arrival of the van at the house, together with instructions as to what should be done prior to its arrival. A form of notice is given on p. 264. The practice of loaning furniture wrappers, owned by the council, to removal contractors is to be recommended. Such wrappers can be treated after use by gas or steam, as and when required. This will prevent any chance of vermin being disseminated after contact with verminous furniture.

When the van is loaded the following points should be borne in mind :—

(*a*) Articles with polished surfaces should be placed in such a position that they are unlikely to come into contact with any heating agents.

(*b*) Chests of drawers containing clothing, and upholstered furniture, should be placed near the doors so that they may easily be removed for airing.
(*c*) The furniture should be loosely packed, diffusion of gas being thereby assisted. Heavy articles should not be placed upon cushions and upholstery.
(*d*) Care should be taken to ensure that no foodstuffs are accidentally placed in the van.
(*e*) A.R.P. civilian gas masks must also be excluded from vans which are to be fumigated or they will be rendered useless.

Bedding should never be treated with hydrogen cyanide unless, as in the case of box spring mattresses, this is unavoidable. Such articles absorb considerable quantities of hydrogen cyanide, which is difficult to remove later.

Before any operations are begun, the first-aid outfit and resuscitation apparatus should be laid out on the windward side of the van or chamber and tested. Gas masks should be tested before operations commence, so that they are ready for instant use. Masks containing the correct filters should be worn when the gas is being introduced and when chambers and vans are unsealed.

In many cases it will be found that occupiers of premises wish to dispose of their old rubbish and furniture for destruction when the remainder is to be fumigated. This should always be disposed of free of charge, since, if this is not done, much of it may find its way into the hands of second-hand dealers with possible disastrous consequences. Such rubbish should be incinerated.

A warning notice should be posted on the following lines :—

Borough of . . . DANGER This van (chamber) is under poison gas. DO NOT ENTER

It is also advisable to have an operator posted nearby to keep a general look-out. After the work has been completed, all residues should be flamed, when, if any cyanide is present, this gas will be burnt off. Residues may then be disposed of on the refuse tip or in the dustbin.

When furniture is tested for the presence of hydrogen cyanide, such tests should always be checked by the supervisor. If the presence of gas is denoted, extra ventilation should always be given. It should be remembered that hydrogen cyanide is not removed by ventilation only, so that all upholstered furniture and carpets, etc., should be removed and thoroughly beaten. This will assist in removal of the gas. As heat and time are required to effect adequate gas removal, it is advisable to transport such articles to a warming room where they may remain until the absorbed gas has been driven off, usually within a maximum period of twelve hours. When delivery is made, the doors of the van should remain open during transit of the furniture.

When the goods arrive at the house they should be divided into two portions, as follows :—

(*a*) *Goods showing no trace of hydrogen cyanide.* These should be placed where the owner requires them.

(*b*) *Goods showing slight traces of hydrogen cyanide gas.*

The latter articles must be placed in a room possessing a flue, while the windows must be opened and wedged. A notice must be affixed to the windows on the following lines :—

> Borough of . . .
>
> This window must be kept open.

The door should be locked and the key taken by the person in charge of operations, the following notice being affixed thereto :—

> Borough of . . .
>
> DANGER
>
> This room must be kept *closed* and *sealed* until its contents have been tested by the Council's Officer.

When furniture is removed for treatment the effects of one tenant only should be placed in the van, in order to prevent any mistake arising through mixing of the furniture. If the fumigation of two lots of effects is unavoidable, they should be divided by means of a steel wire division placed across the van.

Van Fumigation with Heavy Naphtha. Heavy naphtha can be employed in place of hydrogen cyanide for van

fumigation with equal success. There is little doubt that its ease of application and its safety will ultimately be the reasons for its taking the place of hydrogen cyanide for this purpose.

When this liquid is used the heaters should be placed in the floor of the van, while the sides and ceiling should be provided with diffusion screens. The temperature should be raised to approximately 100° F., this temperature being maintained for a period of six hours during which the van is closed. One gallon of heavy naphtha per 750 cubic feet is required for soaking the screens.

Temporary Shelters. The fumigation of household effects by means of hydrogen cyanide may involve the provision of a night's accommodation for the owners of such furniture, although this is by no means necessary in all cases. Many councils, however, who are regularly carrying out this work, have set apart blocks of flats or houses which are used to give shelter to families whose furniture is undergoing treatment.

Such premises are completely equipped homes. The number of rooms, of course, varies, but all facilities, such as gas fires and cookers, water heaters, etc., are provided free of cost to the temporary occupants. The equipment also includes :—

(i) Chairs for each member of the family. These should be provided with stainless steel frames.
(ii) Table and table linen.
(iii) Beds and bedding. The bed frames should preferably be constructed of stainless steel.
(iv) Cooking and table utensils.

Such premises will be occupied by families for at least one night, and sometimes for two nights.

The displaced tenants receive their instructions and

usually move in when their furniture is about to be removed for treatment. They remain until the afternoon of the following day, when their furniture is delivered to their new homes. They should be allowed to bring nothing with them except food and clothing, both of which should be examined by the person supervising the work. Everything else should be prohibited. Bedding used by the temporary occupants should be disinfected and laundered after use.

Premises of this description are a vital necessity in slum clearance work and speedily repay cost of erection and upkeep. When they are provided, freedom of new property from vermin carried by furniture is practically guaranteed. When they are not provided, a re-housing scheme may quickly become heavily infested.

The educational value of furnishing such "decanting" houses tastefully, on a scale within the means of the class of tenant likely to occupy them, cannot be over-emphasised.

CHAPTER X

INSECT CONTROL AND EDUCATIONAL MEASURES

An attempt has been made in the foregoing chapters to describe the habits and environment of various insect pests and to demonstrate how such vermin may be eradicated. Experience has shown clearly that the eradication of vermin cannot be accomplished properly unless those engaged on the task possess a detailed knowledge of the habits and characteristics of the various insect pests. Without such knowledge, all efforts at prevention and eradication are likely to be perfunctory, lacking proper direction and will consequently fail. It must also be remembered that the disinfestation of properties and the work of vermin control are essentially part of the public health service.

The campaign against vermin has received considerable impetus during recent years, chiefly owing to the fact that local authorities have become extensive owners of property built to relieve the existing housing situation and to replace houses demolished as unfit for human habitation. In particular, the rehousing of displaced persons from slum clearance areas has stimulated interest in the prevention of vermin infestation. It is now accepted that, if new houses provided for such displaced persons are to be maintained in a sanitary condition, the problem of preventing such infestation must of necessity

occupy a considerable portion of the time of public health officials. Local authorities do not wish their new properties to become infested with vermin, while the occupiers of old properties are usually amenable to reasoned arguments and are willing, in most instances, even to undergo considerable discomfort in order that their houses and belongings may be rendered free from insect pests.

Attention to the problem of verminous infestation is therefore particularly essential if the infestation which is likely to occur when old houses are replaced with new is to be avoided. Rehousing schemes may easily be invaded with vermin and become heavily infested, unless appropriate preventative measures are taken *and continued* in accordance with an intelligent plan of supervision. The aim of such measures should be to prevent as far as possible the transference of vermin, particularly the bed-bug, to new houses, and to avoid any reintroduction during subsequent occupation. In many housing schemes, vermin infestation has reached serious proportions by reason of the failure of those in authority to realise the extent of the problem and the simplicity with which vermin can be transferred. It is sometimes too readily assumed that such transference of vermin cannot be avoided, although as a result of experience it has been found that proper measures adopted at the correct time will almost obviate the problem.

As an instance of the seriousness of the position, the extent of the bed-bug problem, which is considerable, may be taken. Many different estimates have been given as to its ramifications in London, as many as 50 per cent. of all properties and 70 per cent. of the

population having been stated to be infested to some degree. This is probably an over-statement, as is also that which records the fact that verminous infestation is appreciably greater in London than in the provinces. A more reasonable estimate might be that some 35 per cent. of the properties and 50 per cent. of the population in inner London are infested to a greater or less degree, while this would probably hold good in our large provincial cities and towns. Every local authority is faced with this problem, although some profess to have no knowledge of any infested properties in their districts. In considering this question, it should always be remembered that the bed-bug is no respecter of persons. Not only are slum properties and working-class houses infested, but better-class houses, where strict attention to domestic cleanliness is not observed, are also invaded.

While it is frequently stated that the hot summers of recent years have been responsible for the prolific breeding of the bed-bug, there is little evidence that this is the case, although climatic conditions may possibly have had some slight effect upon the increase shown. A more likely explanation lies in the added attention now being universally paid to working-class properties and insanitary houses generally. Continued effort has been directed since the war of 1914–1918 towards improving the health and the conditions of life of the poorer section of the community. Consequently, the question of vermin and its eradication has become more prominent. In addition, the removal of tenants from old verminous property to new council houses and the general spread of education, with a parallel knowledge covering the value of cleanliness, have stimulated a desire upon the part of such persons to rid their dwellings and furniture of

vermin. It is sometimes stated that bed-bugs constitute one of the factors which create slums, and that once the insects have obtained a foothold in an area that area eventually becomes populated with individuals who tolerate their presence. While this may be so in many cases, by far the greater number of dwellers in infested houses are genuinely anxious to be rid of their tormentors.

Local authorities have also had their attention focussed on the subject following the infestation of council property. It is a disquieting discovery to find that new houses, designed to remove the evils of slum habitation, are rapidly becoming infested ; particularly as local authorities are, as landlords, expected to maintain a high standard of cleanliness in their properties.

Vermin may be controlled at any of the following points :—

(1) New houses.
(2) Existing estates.
(3) Old houses prior to demolition.
(4) Other infested houses.

(1) **New Houses.** Verminous infestation of new houses is particularly important. Vermin may be prevented from entering such premises by effective destruction before the insects reach the houses, hidden in the new occupier's furniture and effects. It is first necessary to decide whether the furniture of every tenant has to undergo fumigation as a preventative measure, or if the effects from infested houses only are to be treated. If the furniture from infested houses only is to be treated, the problem is rendered more difficult, since it is next necessary to discover which tenants possess verminous furniture and premises. The public pillory is of consider-

able assistance in securing agreement as to the treatment of furniture, while the officials must be properly trained to ascertain the different stages of insect development, together with the signs showing evidence of small or large infestations. In dealing with tenants who are to inhabit new council houses, co-operation with the Housing Department is essential. The Housing Manager should provide the Public Health Department with a list of selected tenants for houses. These persons should be visited and their houses inspected by an inspector armed with a torch and also provided with a magnifying lens and a penknife. A thorough and careful inspection of the premises and the furniture should be made. The results of such inspections will enable the houses occupied by the prospective tenants of council property to be divided into three classes :—

(*a*) Not infested.
(*b*) Infested.
(*c*) Doubtful.

In the case of houses which are not infested, further action is obviously unnecessary. Infested houses must be fumigated and the furniture and bedding disinfested before removal to the new houses takes place. Doubtful houses must be visited after an interval of ten days, subsequent action depending on discoveries made at that time. Such procedure, if systematically carried out, will prevent the infestation of any new property.

Several progressive authorities adopt the attitude that *all* property and furniture should be disinfested in the case of removal to council property. Such a procedure has much to recommend it, since, by admitting no distinction, it removes any stigma attached to the process.

(2) **Existing Estates.** In many cases, existing council property will be found in a verminous condition, while cases of infestation will be periodically discovered. The sources of such infestation must of necessity be traced, co-operation with the Housing Department being again essential. Certain rules must be observed, as follows :—

(*a*) All houses previously occupied by the tenants should be visited and inspected, in order to discover any evidence of vermin having been brought with them on removal.
(*b*) Any second-hand furniture bought by the tenants should be disinfested free of charge.
(*c*) The maintenance staff should be instructed to keep a look-out for any traces of vermin, all such infestations being immediately notified.
(*d*) Any houses visited on receipt of a complaint should be inspected for the presence of vermin.
(*e*) When any tenant leaves a house, the premises should be inspected for the presence of vermin prior to their departure. If the presence of such insects is evidenced, the furniture should be treated prior to removal and the house fumigated after their departure.

(3) **Old Houses Prior to Demolition.** Old houses should always be fumigated prior to demolition to ensure that all timber and building materials are free from vermin. Old timber is often sold after demolition and may, in certain cases, be incorporated in other buildings, with subsequent infestation of those premises. Much old timber is sold for firewood and, when stored in the houses of the purchasers, may cause infestation there. Orthodichlorbenzene may be used for the disinfestation of empty houses prior to demolition with considerable success.

(4) **Other Infested Houses.** In dealing with infested houses other than those owned by local authorities, it is essential that the closest co-operation should exist between the landlord, the occupier, and the officials of the Public Health Department. If the local authority offers to carry out the disinfestation of the premises and furniture, it will usually be found that the owner will bear the cost of any structural alteration. The presence of vermin is usually associated with carelessness on the part of the occupier and the absence of good house-keeping and cleanliness. Occasionally, however, the best of houses may become slightly infested owing to the presence of obscure breeding places which may be easily overlooked during the course of ordinary cleansing operations.

The revisiting of the treated properties after disinfestation is an essential which is often overlooked. It is never sufficient to fumigate houses and effects and then to consider that everything has been done. In dealing with furniture, the owners often remove treasures into a neighbour's house prior to disinfestation. Such articles may be verminous and, after disinfestation work has been completed, they may be brought back into new or treated properties, with resulting reinfestation. It will often be found that many persons exercise considerable duplicity so that reliance cannot always be placed upon their word. Women are usually more successful than men in the work of revisiting, since they are more likely to obtain the confidence of the womenfolk, with a consequent improvement in cleanliness.

When inspecting dwellings for the presence of bed-bugs it is very easy to confuse the excreta marks of bed-bugs

with those of flies and other insects. Often the tenant of a house or flat who has recently had his dwelling fumigated against this pest becomes alarmed when fresh excreta marks appear on walls and ceilings, and unless he can be assured that such marks are not fresh evidence of the presence of bed-bugs he continues to worry. Marks left by these insects can, however, be comparatively easily distinguished if it is remembered that the bed-bug has only piercing and sucking mouth-parts and can therefore only consume its food in a liquid state. The house-fly or blow-fly has sucking mouth-parts, but with small peristomial teeth, which permit it to consume small solid particles of food. Spiders, too, have biting and sucking mouth-parts and consume small solid particles of their victims. With the aid of a small, low-powered magnifying glass it is quite easy to distinguish solid particles of undigested material which have been consumed by spiders and flies in their excreta. Having in mind the feeding habits and the mouth-parts of the bed-bug, solid particles can never be found in its excreta.

Bed-bug deposits are not always circular in shape, as are fly or spider spots, but show evidence of the insect having dragged the end of its abdomen in its deposit. Incidentally, these spots are often surrounded by a light-coloured stain, which is caused by a fluid excreted from the Malpighian tubes.

Experiments have shown that bed-bug spots do not fade over a lengthy period of time. Deposits five years old are indistinguishable from fresh excreta marks. Further, if a room has been fumigated with sulphur, thus causing the wallpaper to fade considerably, such fading of the bed-bug spots does not correspond. It is

interesting to note also that there is sometimes very great similarity between the excreta of the American cockroach (*Periplaneta americana*) and that of the house mouse. These are often similar in size and colour, but careful examination will show that the stool deposited by the mouse is usually tapered at either end, whilst that of the cockroach is the shape of a perfect cylinder with blunt ends.

In inspecting property for signs of reinfestation, it is advisable to make use of a detecting liquid. A small hand spray containing the following liquid may be used for this purpose :—

5 parts orthodichlorbenzene.
1 part oil of wintergreen.
50 parts paraffin.

This mixture should be sprayed in likely spots, which should then be examined with the aid of an electric torch. When revisiting, opportunity should always be taken to inculcate the necessity of cleanliness upon the occupiers of the premises concerned. Constant reiteration of this dictum is necessary if the desired effect is to be achieved.

It should always be remembered that no universal remedy exists for the eradication of vermin, because of the adaptability of insect pests to difficulties of environment and feeding, and also because of their well-protected and concealed breeding places.

Educational Measures. Educational measures may be divided into two categories, as follows :—

(1) The education of the official.
(2) The education of the tenant.

The education of the *official* responsible for the execution of the work is of considerable importance.

Such officers should be well versed in the recognition of the different types of vermin, particularly the bed-bug, in all their stages; should possess a knowledge of their life histories and characteristics; and should have an intimate knowledge of the necessary control measures. The Public Health Committee and the members of the local authority generally should also be interested in the work of control.

The responsibility of the local authority as guardian of the health of its district should not, however, end with the disinfestation of furniture and the fumigation of infested premises. Many individuals still look upon vermin as a necessary evil, while others look upon their presence as a disgrace, to be hidden away at any cost. Few, if any, regard infestation as a misfortune. For those reasons sustained effort is required to prevent reinfestation. The argument that an occupier can rid his premises of vermin if he tries should be contradicted, since it is impossible for the tenant, by his own efforts, to do this, particularly if the premises are heavily infested. The public should be told how verminous property may be cleared, how the local authority can help, and how such help may be obtained. The fact that all persons living under verminous conditions require and *are entitled to* assistance should be repeatedly emphasised.

Propaganda judiciously employed is of considerable value. Below are enumerated some of the methods which may be used :—

(1) Distribution of Leaflets. These should explain how infestation may occur, but should make no mention of specific remedies. (For typical leaflets, see Appendix II, pp. 274–283.)

(2) ARTICLES IN THE PRESS. Such articles have considerable value, as they reach a wider circle than leaflets distributed from the office counter.

(3) PUBLIC HEALTH EXHIBITIONS. Demonstrations are of considerable value, the interest of the public being thereby aroused. To this end, an exhibit showing the six stages in the life of a bed-bug is of very great use. To prepare such an exhibit, some 200 bed-bugs are required. These should be divided into five different sizes and placed in separate containers. After several days, eggs will be found. One half of these should be placed in a dish and sterilised with sulphur. The remaining half should be allowed to hatch out so that eventually all stages from egg to adult will be obtained by judicious sorting out. Examples of the males and females of each species of insect pest should also be shown. Exhibits may, if desired, be obtained on loan from the manufacturers of many proprietary insecticides.

(4) CINEMA. Cinema shows possess great educational value. Several films may be obtained quite cheaply, dealing with various insect pests.

(5) DEMONSTRATIONS AT EXHIBITIONS. Demonstrations may be given at a variety of exhibitions, particularly those dealing with housing. An exhibit showing the life history of the bed-bug on the lines mentioned above should be shown. In addition, an actual example of infestation may be shown such as:—

(*a*) Section of skirting or moulding showing bed-bug infestation.
(*b*) An infested piece of upholstery.
(*c*) Infested picture.
(*d*) Infested chair seat.

A composite exhibit illustrating a typical slum dwelling, side by side with a modern Council house, through which the people are allowed to pass alternately, can be made particularly effective.

Simple remedies, including the all-important soap and water, should in any case be demonstrated.

The essence of all propaganda is *simplicity* and *directness* of appeal. This should always be borne in mind when such work is undertaken.

Office Records. Complete office record should be kept of all work carried out. Specimen copies of such records and other forms essential for the purpose will be found in Appendix I, pp. 261–273.

CHAPTER XI

LEGISLATIVE CONTROL

THE legislation dealing with the control of verminous premises and persons, etc., is to be found scattered throughout a variety of Acts. Such Acts are set out in the following pages, together with the Sections applicable to this work. For the sake of brevity all superfluous matter has been omitted.

Public Health Act, 1936

Sec. 83. **Cleansing of Filthy or Verminous Premises.** (1) Where it appears to a local authority upon a certificate of the medical officer of health or the sanitary inspector that any premises used for human habitation—

(*a*) are in such a filthy or unwholesome condition as to be prejudicial to health ; or

(*b*) are verminous,

the authority shall give notice to the owner or occupier of the premises requiring him to take such steps to remedy the condition of the premises by cleansing, disinfecting and whitewashing them, as may be specified in the notice, and in the case of verminous premises the notice may require, among other things, the removal of the wallpaper or other covering on the walls, and the taking of such other steps as may be necessary for the purpose of destroying or removing vermin.

(2) In cases of failure to do the work, the local authority may carry out the necessary works and recover

costs of same. Provides also for fine and daily penalty.

(3) Where a local authority take action under paragraph (b) of subsection (1) of this section, their notice may require that they shall be allowed to employ gas for the purpose of destroying vermin on the premises, but in that case the notice shall be served both on the owner and on the occupier of the premises, and the authority shall bear the cost of their operations and may provide temporary shelter or house accommodation for any person compelled to leave the premises by reason of their operations.

Sec. 84. **Cleansing or Destruction of Filthy or Verminous Articles.** Where it appears to a local authority upon a certificate of the medical officer of health or the sanitary inspector that any article in any premises—

(*a*) is in so filthy a condition as to render its cleansing, purification or destruction necessary, or dangerous or injurious to the health of any person in the premises; or

(*b*) is verminous, or by reason of its having been used by, or having been in contact with, any verminous person is likely to be verminous,

the local authority shall cause that article to be cleansed, purified, disinfected or destroyed, as the case may require, at their expense and, if necessary for that purpose, to be removed from the premises.

Sec. 85. **Cleansing of Verminous Persons and their Clothing.**

(1) Upon the application of any person, a county council or a local authority may take such measures as are, in their opinion, necessary to free him and his clothing from vermin.

(2) Where it appears to a county council or a local authority upon a report from their medical officer of health or, in the case of a local authority, from

their sanitary inspector, that any person, or the clothing of any person, is verminous, then, if that person consents to be removed to a cleansing station, they may cause him to be removed to such a station, and, if he does not so consent, they may apply to a court of summary jurisdiction, and the court, if satisfied that he or his clothing should be cleansed, may make an order for his removal to such a station and for his detention therein for such period and subject to such conditions as may be specified in the order.

(3) When a person has been removed to cleansing station, the authority may take such measures as are necessary to free that person or his clothing from vermin.

(4) Cleansing of females to be carried out only by a registered medical practitioner or by a duly authorised woman.

(5) Consent to cleanse person under sixteen years of age may be given by his parent or guardian.

(6) No charge to be made for cleansing person or his clothing.

(7) Powers under this section given to any local authority or county council are in addition to those exercised by them as a local education authority.

Sec. 86. **Provision of Cleansing Stations.** A county council or a local authority may provide such cleansing stations as may be necessary for the discharge of their functions under any of the three last preceding sections.

Public Health (London) Act, 1936

Sec. 122. **Cleansing or Destruction of Verminous Articles.** (1) Where it appears to the sanitary authority on a report of a district medical officer of health . . .

(*c*) that any such article is infested with vermin or, by reason of having been used by any person infested with vermin, is likely to be so infested,

the authority may cause the article to be cleansed disinfected or destroyed and (if they think fit) removed for that purpose.

Compensation. (2) Provides for compensation to be given for any damage done to article or for any article destroyed. Compensation payable may be recovered as a civil debt.

Enforcement. (4) Emphasises that it is the duty of every sanitary authority to enforce the provisions of the section.

Definition. (5) Definition :

" House " does not include factory, workshop or laundry to which the Factory and Workshop Act applies or any building within the Port of London not used wholly or in part as a dwelling house or stable.

Sec. 123. **Cleansing of Verminous Houses.** (1) Where it appears to a sanitary authority that any house or part of a house in their district is infested with vermin, the authority shall serve a written notice on the owner or the occupier of that house requiring him, within such period as may be specified in the notice, to cleanse the house or part or such portion as may be specified and may, by the said notice, require him to remove wallpaper from the walls of the house or part or portion thereof so specified and to take such steps for the purpose of destroying and removing vermin as the case may require.

Penalty. (2) Provides for penalty for failure to comply with such notice and sanitary authority may carry out any work required to be done and recover expenses.

Proceedings. (3) When any proceedings under this section are taken, the court may enquire whether any requirement contained in a notice served or whether any work done by the sanitary authority under this section was reasonable and whether expenses have to be borne wholly or in part by person on whom notice was served. Court may

make an order concerning expenses or their apportionment.

Right of Entry. (4) Gives power of entry to inspect house or part of house supposedly infested with vermin and to see if works necessary have been completed.

Enforcement. (5) Emphasises duty of every sanitary authority to enforce provisions of this section.

Sec. 124. **Provision of Cleansing Stations.** (1) Empowers sanitary authority to provide cleansing stations for verminous persons and stations for the cleansing and destruction of verminous articles together with the necessary apparatus for the cleansing of verminous articles and houses.

(2) Empowers two or more sanitary authorities to act in combination for the purposes of this section.

(3) The sanitary authority may borrow money with the consent of the Minister of Health for the purposes of this section.

Sec. 125. **Use by Verminous Persons of S.A.'s Apparatus.** (1) Any person infested with vermin may apply to the sanitary authority for use of apparatus to cleanse himself and free use may be granted by the sanitary authority of any apparatus which they possess.

Sec. 126. **Cleansing of School Children and Inmates of Common Lodging Houses.**

(1) County medical officer of health or any person authorised by him in writing may in any county council school examine the person or clothing of any child attending school and if the person or clothing of any such child is infested with vermin, a notice may be served on the parent or guardian requiring him to properly cleanse the person or clothing of the child within twenty-four hours of receipt of the notice.

(2) Gives similar power to deal with an inmate of a common lodging house whose person or clothing is in a verminous condition, such person to be dealt with at a specified cleansing station.

(3) If the notice is not complied with, such child or inmate of a common lodging house when verminous, may be removed to a cleansing station and such persons may be detained there until the cleansing required by the notice has been carried out.

(4) Requires the production by the person authorised of his authority when demanded.

(5) Provides penalty for obstruction.

Sec. 127. **Cleansing of Verminous Persons by Order of Court.** (1) If any person or clothing of such person is infested with vermin and the person does not consent to be removed to a cleansing station, the sanitary authority may apply to a petty sessional court for an order to remove such person and deal with that person and clothing at a cleansing station. The court may, if satisfied, grant the order for the removal and cleansing of such person.

(2) When person has been removed to a cleansing station under such order the sanitary authority shall take such measures to free him and his clothing from vermin as they think necessary.

(4) No charge may be made for the cleansing or removal of an infested person or his clothing.

(6) Provides penalty for disobedience of order or for obstruction.

Definition:

"Vermin" includes bugs, fleas, lice and itch mites and their eggs, larvæ and pupæ.

This definition is similar to that given in the Public Health Act, 1936.

Public Health (Infectious Diseases) Regulations, 1927

It is specified in these Regulations that the medical officer of health may, by written notice, require the temporary segregation of the contacts of a case of typhus fever or relapsing fever till such persons are completely freed from lice.

Housing Act, 1936

Sec. 17. **Power of Local Authority to Cleanse from Vermin Building to which Demolition Order Applies.**

(1) If it appears to the local authority that a house, to which a demolition order made under this part of this Act applies, requires to be cleansed from vermin, the authority may, at any time between the date on which the order is made, and the date on which it becomes operative in relation to the house, serve notice in writing on the owner or owners of the house that the authority intend to cleanse it before it is demolished.

(2) A local authority who have served a notice under the foregoing subsection may, at any time after the order has become operative in relation to the house and it has been vacated, enter and carry out such work as they may think requisite for the purpose of destroying or removing vermin, and the demolition of the building shall not be begun or continued by any owner after service of the notice upon him until the authority have served on him a further notice authorising him to proceed with the demolition.

Provided that an owner upon whom a notice has been served under the foregoing subsection may, at any time after the house has been vacated, serve notice in writing on the authority requiring them to carry out the work within fourteen days from the receipt of the notice served on him, and at the expiration of that period shall be at liberty to proceed with the demolition of the building whether the work has then been completed or not.

(3) Where a local authority serve a notice under subsection (1) of this section, subsection (1) of section 13 of this Act (dealing with procedure where demolition order is made) shall have effect in relation to the house to which the notice relates subject to the proviso that the local authority shall not be entitled to take action thereunder until the expiration of

six weeks from the date on which the owner or owners become entitled by virtue of subsection (2) of this section to proceed with the demolition.

It should be noted that in London the medical officer of health may make a report to the local authority if the sanitary inspector has seen the house, personal inspection of the premises being unnecessary. In the provinces, however, the house must be inspected by the individual who issues the certificate, whether such individual be the medical officer of health or the sanitary inspector.

Hydrogen Cyanide (Fumigation) Act, 1937

Sec. 1. This section gives power to the Secretary of State to make Regulations—

(*a*) To regulate the manner in which hydrogen cyanide may be generated and to require the admixture of hydrogen cyanide with any other substance.

(*b*) To prohibit fumigation with hydrogen cyanide by untrained persons.

(*c*) To regulate disposal of residues.

(*d*) To specify tests to be used to ensure that premises are free of gas.

Penalties for non-compliance with the regulations are also provided.

Sec. 2. Whenever any accident which occasions loss of human life or personal injury occurs as the result of the fumigation of any premises, or article, the person by whom or by whose agent the fumigation was carried out shall send forthwith to the Secretary of State notice of the accident and of the loss of human life and personal injury.

Penalty is provided for non-compliance.

Sec. 3. Gives power to the Secretary of State to hold an inquiry into any accident of which notice has been given.

Sec. 4. States that the provisions of the Act may be

extended to cover fumigation with any substance other than hydrogen cyanide by means of Order in Council.

Hydrogen Cyanide (Fumigation of Buildings) Regulations, 1938

These Regulations were formulated under powers provided by Section 1 of the Hydrogen Cyanide (Fumigation) Act, 1937.

Art. 1. This article contains the definitions as follows .—

"Fumigation" means the fumigation with hydrogen cyanide of any building or part thereof.

"Fumigant" means hydrogen cyanide.

"Undertaker" means any person carrying out the *fumigation* under contract or otherwise.

"Operator" means person designated in writing by the *undertaker* to be in charge of carrying out the *fumigation*.

"Fumigation area" means building or part of a building undergoing *fumigation*.

"Risk area" means part of a building to which there is any reason to apprehend that the *fumigant* may penetrate from the *fumigation area* and in any case includes those parts of any building which are less than 30 feet from the nearest boundary of the *fumigation area* unless separated from the *fumigation area* by a yard, street or other open space not less than 10 feet in width.

"Prescribed" means prescribed by the Secretary of State.

"Medical Officer of Health" means the Medical Officer of Health of the district in which the *fumigation area* is situate.

Art. 2. (1) It shall be the duty of the *undertaker*—

(*a*) To observe the requirements of the regulations 3 (1) and (2), 4 and 13 (1), (2) (a) and (3);

(*b*) To take such steps as may be necessary to enable the *operator* to carry out the requirements of the regulations 3 (3) and 5 to 9 inclusive, 11, 12 and 13 (2) (b) ; and

(*c*) Generally to exercise such supervision and take such steps as are within his power to secure the due observance of the regulations by those engaged by him to carry out a *fumigation*.

(2) It shall be the duty of the *operator* to secure that the requirements of regulations 4 (3), 5 to 13 inclusive, and 13 (2) (b) are complied with and all other persons employed in connection with the *fumigation* to co-operate with the *operator* for that purpose.

Art. 3. (1) Notice in writing of any forthcoming *fumigation* stating the description of the *fumigation area* and of the *risk area* and the date and time at which the *fumigation* will be commenced shall be sent to the officer in charge of the police station nearest to the *fumigation area* and to the *Medical Officer of Health* ; this notice shall be sent so as to reach them not less than forty-eight hours before the time of commencement of the *fumigation* unless otherwise arranged with each of the officers concerned.

The obligation for service of notice on the medical officer of health exists as that official may often be able to render valuable assistance to fumigators on account of his intimate knowledge of local conditions in fumigation and risk areas. Thus any points regarding the repair of the property to be treated can be brought to the notice of the undertaker together with any other questions which may arise.

Art. 3. (2) Any further particulars as to the carrying out of the *fumigation* which may be asked for by the *Medical Officer of Health* shall be supplied.

(3) In cases in which any part of the *fumigation area* is used for the business of the manufacture or storage

of foodstuffs the *undertaker* may apply to the *Medical Officer of Health* for certificate of exemption from the obligations of regulation 5 (b) with regard to foodstuffs in the *fumigation area* and on such application, the *Medical Officer of Health* may grant such a certificate on such conditions stated in the certificate as he may think necessary to prevent danger from the contamination of such foodstuffs by exposure to the *fumigant* and on the grant of any such certificate the obligations of regulation 5 (b) shall cease to apply to the *fumigation* in respect of which the certificate has been granted and the conditions stated in such certificate shall be complied with.

Provided that the *Medical Officer of Health* shall not either unreasonably refuse to grant such a certificate or impose unreasonable condition therein.

This duty of granting certificates of exemption is the only one which is specifically imposed upon medical officers of health. Exemption under this section is intended to apply mainly to warehouses in which foodstuffs such as sugar, cocoa, flour, wheat or grain are stored in large quantities.

Art. 4. (1) No *fumigation* shall be carried out except by an adequate fumigating staff.

(2) One member of the fumigating staff shall be designated in writing as the *operator* in charge of the *fumigation*.

(3) The *operator* shall have had not less than six months regular experience of *fumigation* together with, in addition, twelve months regular experience of fumigating with the *fumigant* one or both of the following, namely, buildings and ships, and shall be otherwise competent for the purpose.

(4) The fumigating staff shall in all cases include two persons both of whom shall be adequately trained in first aid.

Art. 5. The *fumigant* shall not be liberated until—

(*a*) all persons other than the fumigating staff have left the *fumigating area* and the *risk area* and, for the purposes of paragraphs (a), (b), (c) and (d) of this regulation, an exhaustive search has been carried out; and

(*b*) all liquids or foodstuffs of such a kind or so stored as to be liable to absorb the *fumigant* have been removed from the *fumigation area*; and

(*c*) all fires and naked lights in the *fumigation area* have been extinguished; and

(*d*) every door or other means of access to the *fumigation area* or to the *risk area* has been securely fastened so as to prevent access thereto and possession has been taken of the keys; and

(*e*) notices containing, in block letters not less than 2 inches in height, the words "DANGER: POISON GAS: DO NOT ENTER" have been placed where they may readily be seen by any person approaching the *fumigation area* or the *risk area*; and

(*f*) all practicable steps have been taken to seal all openings, cracks or crevices so as to prevent the escape of the *fumigant* from the *fumigation area*; and

(*g*) the appropriate entries have been made in the *prescribed* register.

Art. 6. The *fumigant* shall not be applied in such a manner as to be absorbed in liquid form by floors, walls, ceilings or household effects; nor in such quantities as to effect an average concentration exceeding 4 parts in 100 in any room or other part of the building.

Art. 7. After the liberation of the *fumigant* has commenced and until the *fumigation area* and *risk area* are free from danger—

(*a*) any member of the fumigating staff being in any part of those areas shall wear or carry ready for immediate use an efficient mask or other apparatus which affords complete protection to the wearer against the *fumigant;* and shall carry or have in his possession ready for immediate use an efficient electric torch ; and

(*b*) there shall be constantly available first aid appliances and remedies, which, if any types of appliances or remedies have been *prescribed*, shall comply with the requirements and conditions of such prescription.

Art. 8 No person other than a member of the fumigating staff shall be permitted to enter the *fumigation area* after *fumigation* until—

(*a*) the *fumigation area* has been ventilated in such manner and for such period, which period shall not be less than twenty-four hours in the case of dwelling houses, as shall be effective to secure that the area is free from danger ; and

(*b*) it has been established by tests, which, if any tests have been *prescribed*, shall be the *prescribed* tests, that the area is free from danger ; and

(i) an entry to that effect has been made in the *prescribed* register, and

(ii) a certificate to that effect has been delivered or despatched to the *Medical Officer of Health ;* and

While the Secretary of State is empowered under this portion of the Regulations to prescribe tests to be used in fumigation work where hydrogen cyanide is employed, it is not intended to make any prescription for the present until further experience in the working of the Regulations has been obtained.

(c) all vessels or residues of the materials used for generating the *fumigant* have been removed and safely disposed of; and

(d) all water contained in cisterns, tanks or otherwise in the *fumigation area* which may have become contaminated by the *fumigant* has been run off.

Art. 9. No person other than a member of the fumigating staff shall be permitted to enter the *risk area*—

(a) while there is a high concentration of the *fumigant* in the *fumigation area*, and

(b) until—

(i) the *risk area* has been ventilated in such manner and for such period as shall be effective to secure that the area is free from danger, and

(ii) it has been established by tests, which, if any tests have been *prescribed* shall be the *prescribed* tests that the area is free from danger, and an entry to that effect has been made in the *prescribed* register.

Art. 10. During the period in which the *fumigation area* is under a high concentration of the *fumigant* steps shall be taken to keep under observation the *risk area* and any buildings adjoining the *risk area* in order to ensure the discovery of any penetration of the *fumigant* into such buildings; and, in the event of any such penetration being discovered, all steps which are reasonably practicable shall be taken to safeguard any occupants of such buildings.

Art. 11. During the period in which the *fumigation area* is under a high concentration of the *fumigant*, at lease one member of the fumigating staff who shall have possession of all keys of which possession has been taken in accordance with No. 5 (d) of these regulations shall remain in attendance and thereafter until the *fumigation area* and the *risk area*

have been certified to be free from danger, a member of the fumigating staff shall either be in attendance or if a responsible person employed by or acting under the directions of the *undertaker* for the purpose is in attendance. shall be readily available.

Art. 12. All bedding, blankets, pillows, clothing, cushions and upholstered articles likely to absorb the *fumigant* which have been exposed to the *fumigant* shall, before the return of any occupants, either—

(*a*) have been treated in such manner and for such period as shall be effective to secure that they are free from danger and have been ascertained by tests, which, if any tests have been *prescribed*, shall be the *prescribed* tests, to be so free ; and

(*b*) be removed from the *fumigation area*, and shall not be restored thereto until they have been treated and tested as required in paragraph (a) of this regulation.

Art. 13. (1) A register or registers in *prescribed* form in which the *prescribed* particulars shall be entered in the *prescribed* manner, shall be provided and shall, except when in use by the *operator* for the purpose of paragraph (2) (b) of this regulation, shall be kept at the office of the *undertaker*.

(2) In connection with each *fumigation*—

(*a*) a register as aforesaid, in which any particulars required to be entered by the *undertaker* prior to the *fumigation* shall have been entered, shall be handed to the *operator ;* and

(*b*) any particulars required to be entered in such register by the *operator* shall, at the appropriate times, be entered by him.

(3) Any such register shall be preserved in good condition until a period of two years has elapsed from the date of the last entry.

Art. 14. This article gives exemption to fumigation for agricultural and horticultural purposes and for fumigations carried out in specially constructed chambers.

The Regulations came into force on February 1st, 1939.

Liverpool Corporation Act, 1936

An interesting section incorporated in this Act gives specific power to deal with infested articles in second-hand dealers' shops. It also renders it an offence to expose such verminous articles for sale.

CHAPTER XII

HUMAN TOXICOLOGY

Introductory. The handling of poison gases always entails a certain degree of accidental risk. Particularly is this the case with hydrogen cyanide which is, if inhaled, quickly fatal to human beings.

A poison may be defined as any substance which, on being absorbed into the organs, or by chemical action upon the tissues, injures health or destroys life. These substances act in various ways, which may be briefly summarised as follows :—

(1) By burning the parts touched, such as the mouth, throat and stomach. These are either acids or alkalies and are known as *corrosive poisons.*

(2) By irritating the portions of the body touched, causing sickness, inflammation or diarrhœa. These are known as *irritant poisons* and are usually metal salts.

(3) By absorption into the blood stream. These are *narcotic poisons* and affect the brain and heart.

(4) By generally affecting the constitution, in addition to producing a local irritant effect. Strychnine is an example of this class of toxic agent.

Effect of Hydrogen Cyanide on the Body. Hydrogen cyanide is an exceedingly dangerous poison. It is unusually volatile, while if inhaled it will produce death within a few seconds. Its purchase, handling and

disposal are governed in most countries by statutory ordinances. Poisoning by hydrogen cyanide may occur by inhalation of the gas, by means of absorption through the skin, or by swallowing. In dealing with poisoning by means of hydrogen cyanide during fumigation work, however, ingestion of the salts or the gas need not be considered.

Hydrogen cyanide acts on many forms of life and is known as a *protoplasmic poison*. It does not cause any destruction of tissues. One-twentieth of a grain is fatal to man. Concentrations approaching 1 volume per cent. for one hour represent the limit of safety of the average gas mask with an absorption filter. Although victims describe their symptoms in different ways, the general effect of inhaling the gas is more or less constant. The following table, published by Associated Fumigators

TABLE 2

H.C.N. Parts per 1,000	Odour	Breathing Time Limit	Effects	Test Paper
1	Very strong.	Not to be breathed.	Immediate loss of consciousness, with fatal results.	Blue/Black colour immediately.
0·1–0·2	Strong.	30 mins. to 1 hour.	Progressive dizziness and sickness. Increasing lack of power in limbs.	Blue colour immediately.
0·01–0·02	Perceptible.	Several hours.	Headache and nausea.	5 secs. medium blue, 40 secs. dark blue.
0·001	Feebly perceptible.	—	Seldom harmful.	Commences to change at 25 secs. 1 min. pale blue. 2 mins. decided colour.

Ltd., gives a tabulation of approximate results following inhalations of hydrogen cyanide, together with the effects on the Sievert and Hermsdorff reagent.

One volume of gas per 1,000 cubic feet will prove fatal. When a strong concentration is inhaled there may be no premonitory symptoms. The lethal effect is almost instantaneous, the person affected falling to the ground with a convulsive movement. Immediate unconsciousness results, followed by death within a few seconds. The inhalation of lower concentrations varies in its effect upon different individuals. Normally the symptoms are :—

(1) A sense of irritation in the throat with salivation and numbness of the mouth and pharynx.
(2) Increased difficulty in breathing.
(3) Watering of the eyes, with occasional dilation of the pupils.
(4) General weakness of the legs.
(5) Headache, nausea and vomiting.
(6) Pallor and increasing dizziness.
(7) Unconsciousness, with convulsions and evacuation of the bladder and bowels.
(8) Cessation of breathing.

Most persons who regularly handle hydrogen cyanide have, at some time or another, inhaled a portion of the gas, and such individuals may have experienced nausea and vomiting.

The effect of hydrogen cyanide is primarily stimulation of the nervous system, followed by paralysis of the respiratory centre situated in the medulla oblongata. The peripheral muscles are affected, the breathing may become accelerated, while in larger doses respiration may cease for a temporary period and thereafter

recommence. The poison also acts upon the circulatory system. A rise occurs in the blood pressure, followed by a sudden fall, cardiac action being slowed down. The effect of the gas upon the tissue cells is to inhibit their ability to utilise oxygen. This suspension of oxidation is maintained only during the presence of the gas, the normal function returning when the gas is removed, always providing that death has not intervened during the period of oxygen starvation. The toxic effect of hydrogen cyanide depends upon the quantity attacking the body at any given time, and not so much upon the total quantity absorbed. Hydrogen cyanide is rendered harmless in small doses, so long as the body can regenerate the blood. In large doses the blood assumes an almost pink coloration.

Suffocation can be avoided if the hydrogen cyanide is diverted from the cells and distributed as quickly as possible throughout the body by natural or artificial respiration. If the hydrogen cyanide can be deprived of its toxicity before the respiration is paralysed and heart failure occurs, the patient will recover without any after-effects.

Should any symptoms indicative of poisoning occur following the inhalation of hydrogen cyanide, immediate action must be taken. These steps may be summarised as follows :—

(1) The affected person should be moved into the open air. Depending on the degree of consciousness, he should be made to walk about quickly, facing the wind, with his arms over the shoulders of two helpers, or if nearly unconscious should be allowed to lie down. Walking will assist in promoting rapid circulation of the blood, but exertion in a weakened state may cause heart failure. The rescuers should

wear masks. The following antidote for hydrogen cyanide may be given to persons who are conscious :

(*a*) 158 grams of ferrous sulphate crystals dissolved in 1 litre of water.

(*b*) 60 grams of anhydrous sodium carbonate dissolved in 1 litre of water.

Equal volumes of the liquids, *i.e.*, 50 c.c. of (*a*) and (*b*) make the requisite dose which should be taken immediately. Deep breathing is of considerable assistance, while if the patient is able to swallow, very strong coffee should be given. If the symptoms are severe, a hypodermic injection of 2 grains of caffeine sodium benzoate should be administered. If the person affected is incapable of movement, the administration of oxygen and artificial respiration should be resorted to at once.

(2) The patient should be placed in a recumbent position with head to the windward and should not be forced to walk, since this places a strain upon the heart.

(3) If the breathing shows signs of failing, the Schafer system of artificial respiration should be immediately commenced and carried on energetically for as long as twelve hours if necessary. When respiration has been established, the treatment can be stopped, but the patient must be watched carefully in case of relapse. The administration of oxygen should, however, be continued.

(4) Clothing round the upper portion of the body should be cut away as quickly as possible. It is important to remember that such clothing may retain quantities of gas.

(5) The patient must be wrapped in blankets, with hot water bottles at his feet.

(6) A doctor should be summoned. If the pulse and breathing are no longer perceptible, an intravenous injection of 5 c.c. coramine (Clayton aniline) or an intra-muscular injection of 0·01 c.c. lobelin hydrochloride should be given. Subcutaneous

injections of a 5 per cent. solution of thiosulphate in doses up to 100 c.c. are also recommended. If lobelin is not available a hypodermic injection of $\frac{1}{25}$th grain atropine or $\frac{1}{12}$th grain strychnine may be given. These doses may be repeated after an interval of ten to fifteen minutes.

(7) Amyl nitrite should be inhaled by the patient for three to five minutes, each individual inhalation lasting for fifteen to thirty seconds.

(8) If the cardiac action has apparently ceased, stimulation should be applied by the injection of caffeine or 3 c.c. coramine. *It is important to note that stimulation of the heart should be left to a medical practitioner.* Intravenous injections of a mixture of oxantine with colloidal sulphur have been employed to restore mice which have been subjected to a ten-fold toxic dose of hydrogen cyanide, and which appear to have succumbed. This method has not, however, been applied to human beings, although it would appear to offer considerable possibilities.

A first-aid case containing the following specifics should always be available for instant use :—

2 tubunics with 0·01 gram lobelin each.
2 tubunics with 0·25 gram caffeine each.
Capsules with tincture of iodine.
2 rolls of adhesive plaster, each 1 yard long by 1 inch wide.
1 special dressing plaster.
1 roll of army bandage.
2 rolls gauze binding, each 4 yards long by 2 inches wide.
1 pair of forceps.
Safety pins.
1 pair of scissors.

Such an outfit can be obtained in handy pocket size.

Artificial Respiration. Body cells depend for their

efficiency upon the maintenance round them of certain factors :—

(*a*) Temperature.
(*b*) Oxygen and carbon dioxide tension.
(*c*) Osmotic pressure.

When a person is in a state of asphyxia, the oxygen and carbon dioxide tension is reduced. This is accompanied by a fall in temperature.

The most important factor in commencing artificial respiration is that of *time*. If a period of eight minutes has elapsed since the patient became unconscious, it is useless to try to resuscitate the affected person, although it should be noted that the heart may beat for some time after breathing has ceased. The availability of the oxygen supply depends upon the temperature of the blood. For this reason the body must be kept warm. The *Schafer system of artificial respiration* possesses the following advantages :—

(1) Easy to learn.
(2) Easy to apply.
(3) Easy to maintain.
(4) Unlikely to harm the patient in any way since it is entirely mechanical.

The following procedure should be immediately carried out by the rescuer, wearing a mask :—

(1) Patient should be removed to a pure atmosphere.
(2) Rescuer should feel with fingers in patient's mouth and throat and remove foreign bodies, *i.e.*, dentures, etc. If the mouth is tightly shut, no unnecessary time should be lost in trying to open it.
(3) Resuscitation should be commenced immediately. Do not stop to loosen clothing, as any delay may be serious or even fatal.

(4) Patient should be laid on stomach with head to the windward, one arm extended directly overhead, the other bent at the elbow. The face, which is turned outwards, should rest on the hand or fore-arm, so that the nose and mouth are free for breathing.

(5) If breathing appears to have ceased, the rescuer should kneel, straddling the patient's thighs, with his knees close to the hip bone.

(6) The palms of the hands should be placed on the small of the back with the fingers resting on the ribs. The little finger should just touch the lowest rib with the thumb and finger in a natural position, the tips of the fingers being out of sight.

(7) The arms should be held straight and the body swung slowly forward, so that its weight is gradually brought to bear upon the patient. The shoulder should be directly over the heel of the hand at the forward swing. The elbows should not be bent and the operation should occupy approximately ten seconds.

(8) The body should be immediately swung back to remove the pressure completely.

(9) After two seconds the forward swing should again be repeated.

(10) The movements of compression and release should be repeated twelve to fifteen times per minute.

(11) This procedure should be carried on without interruption until breathing is restored or until a doctor declares that life is extinct.

(12) An assistant if available should apply the resuscitation apparatus described below.

Resuscitation Apparatus. Any resuscitation apparatus should be simple as to use and reliable in operation. The two types of apparatus in common use are :—

(1) The "Novox."
(2) The "Novita."

(1) THE "NOVOX." This apparatus administers dicarbox gas which is a mixture of 93 per cent. oxygen and 7 per cent. carbon dioxide. The two cylinders each contain 15 cubic feet of gas under a pressure of 150 lb. per square inch, while the breathing bag comprises a lung-operated mechanism connected by means of a flexible rubber tube to a face mask.

To use the apparatus, the cylinder and the control valves are opened. The mask is placed over the patient's face, care being taken to ensure that it fits properly and that it is held securely in position. The air admission orifice and the shutter in the mask must be kept closed. Dicarbox gas is automatically delivered by the patient's own respiratory efforts, provided the patient is able to breathe at all. The breathing bag collapses, and in doing so actuates levers controlling the gas admission valve. The state of the patient's breathing can be judged by watching the breathing bag.

If breathing is shallow or appears to have ceased, the dicarbox gas can be administered independent of the breathing bag, by opening the by-pass valve. When this is done, the gas passes direct from the cylinder to the mask by means of the breathing bag. Care must be taken to ensure that the bag is not over-inflated. When the patient's breathing becomes normal, the by-pass valve is closed and gas is again administered by means of the patient's own inspirations. When normal breathing has been maintained, the air admission orifice is opened and the quantity of gas reduced. By increasing the size of the orifice, the patient breathes more air and less gas until eventually, by the gradual closing of the gas valve, the patient is breathing atmospheric air only.

A pressure gauge indicates the point at which the first cylinder employed is almost empty. When this occurs, the other cylinder is used. The orifice and exhaling valve should receive periodical examination.

(2) THE "NOVITA." This apparatus is rather different in appearance from the type previously described, the principle, however, remaining the same. The steel cylinder contains 10 cubic feet of oxygen at a pressure of 1,800 lb. per square inch. This is released by means of the main valve and the inlet valve to the flexible bag, when it passes to the face mask. It is operated in a similar manner to the Novox apparatus.

Absorption of Hydrogen Cyanide through the Skin. When the body is exposed for long periods to high concentrations of hydrogen cyanide, harmful quantities of the gas may be absorbed through the skin. Whilst excessive absorption is fatal to animals, it is not known to act in a similar way towards human beings. The skin shows a bright red coloration, while the affected person feels heavy and sick, and finds difficulty in breathing. This feeling of nausea is evident for some time before the danger point is reached, so that the affected individual is afforded ample opportunity to reach the open air. Operators should always be removed from a gaseous atmosphere at intervals in order to air their bodies and inhale fresh air. If this is done, the dangers of absorption will be very largely negatived.

Gas Masks. When working in gaseous atmospheres such as those experienced in the fumigation of property, it is obviously essential that gas masks should be worn, not only as a means of protection to the operators concerned, but also to prevent inconvenience to others. The gases used may not all be toxic to human beings,

but even in such cases their heavy concentration may render entrance difficult and excessively uncomfortable.

There are several reliable types of mask in use, which are suitable for this type of work. These should conform to the following conditions :—

(1) Should be simple to operate.
(2) Should be light in weight.
(3) Should be no encumbrance to the wearer.
(4) Should possess lenses giving a wide field of vision.
(5) Eye-pieces should be fitted with transparent composition discs to prevent any condensation arising thereon.
(6) The filter should offer a minimum of breathing resistance.

The " *Degea* " mask is admirably suited for use during fumigation work, affording a high degree of protection against many gases according to the type of filter used, while possessing the minimum breathing resistance. The mask is really a soft leather face shield which is fitted with adjusting tapes, a gas absorption filter or canister, and eye-pieces. The eye-pieces are composed of Triplex glass and are non-shatterable, while the condensation of moisture on the glass is prevented by transparent composition discs. These are fixed inside the eye-pieces and can be renewed when clouded. The masks are obtainable in three sizes :—

Size 1 . .	Largest size.
Size 2 . .	For the average sized face.
Size 3 . .	Small size.

The mask is drawn over the head until it fits smoothly against all portions of the face. The straps are then

tightened up. When firmly fixed in position, the operator should place the flat of his hand against the recessed metal mouthpiece and should inhale. If any air is drawn in, the fitting is not satisfactory. Adjustments should then be made or another mask fitted. The gas absorption canister is screwed into the recessed metal mouthpiece. It is fitted with a screwed cap above, while the base is covered with a special waterproofed fibre lining which has a metal ring inserted in its centre. When the canister is fitted to the mask, the metal cap and fibre covering are removed, exposing the perforated plate. The rubber washer in the recessed mouthpiece is slightly damped and the canister screwed tight against this washer. When fitted, it is advisable to breathe through the canister for a few minutes, in order to introduce a small quantity of atmospheric moisture to the neutralising ingredients.

Filters or canisters may be obtained which afford a protection against a variety of gases. Below are given particulars of the various types of filters.

Initial	*Gas*	*Colour*
G	Hydrogen cyanide.	Blue.
J	Zyklon.	Blue with brown band.
A	Etox, orthodichlorbenzene or heavy naphtha.	Brown.
E	Sulphur.	Yellow.

The effectiveness of the canister is never exhausted suddenly, but permits ample time for the fumigator to leave the building and adjust fresh apparatus. Extra canisters should always be available for all masks in use. In the ordinary routine concentrations such as are used for house fumigation, protection is given for approximately ten hours' continuous use. In heavy concentrations, this period would be considerably reduced.

Operators are, however, rarely exposed to the gas for any considerable time, so that the canisters have a reasonably long life. Their renewal is indicated by the slight taste of gas, and the presence of tear gas inside the mask. Discarded canisters should be mutilated or destroyed, to avoid any risk of their being used again in error.

The "*Puretha*" respirator is also a useful type of mask. The face-piece is made of rubber, the exterior of which is covered with elastic fabric. Eye-pieces of splinterless glass are provided, the inspired air being drawn over these to clear the condensed moisture. The mask is held securely in place by means of adjustable elastic straps. A flexible corrugated breathing tube of elastic-faced rubber connects the face-piece to a canister of chemical absorbent which is held in an adjustable neck sling. The canisters may be obtained for use with a variety of gases, as follows ;—

Initial	*Gas*	*Colour*
D	Hydrogen cyanide.	White.
SH	Sulphur dioxide.	Red with white stripe.
C	Orthodichlorbenzene, formaldehyde, and heavy naphtha	Black.

CHAPTER XIII

THE DISINFESTATION OF FOODSTUFFS

THE disinfestation of foodstuffs presents a difficult problem, entirely different from that which confronts the operator when insect pests in premises and furniture are concerned. The difference arises from the fact that foodstuffs must be treated in such a way as to destroy insect pests without causing any deterioration in quality of the foodstuffs concerned, and without danger to the subsequent consumer.

With few exceptions, the problems arising from the disinfestation of foodstuffs still remain to be settled. Considerable research work must yet be done before the work can be simplified and placed upon a sound basis. Before dealing with the methods employed, some knowledge of the pests attacking foodstuffs is essential. These insects may be divided into two main groups :—

(1) Beetles (Coleoptera).
(2) Moths (Lepidoptera).

Cereals are chiefly attacked, although only a few of the varieties of insects responsible can survive the winter climate of this country.

(1) **Beetles.** In this class are to be found three weevils and one beetle, all of which assume considerable importance. These are :—

(*a*) *Sitophilus granaria* or grain weevil.
(*b*) *Sitophilus oryzæ* or rice weevil.

(*c*) *Caulophilus latinasus.* This weevil is often found in grain, but more often in spices.
(*d*) *Trogoderma granaria*—a beetle of the Dermestidæ family.

The aforementioned insects attack the whole grain before it has been ground. When the grain has been ground into flour it is attacked by a second series of insects, most important among which are :—

(*e*) *Tribolium castaneum.*
(*f*) *Tribolium confusum.*

Two other beetles frequently met with in flour are :—

(*g*) *Tenebrio molitor.*
(*h*) *Tenebrio obscurus.*

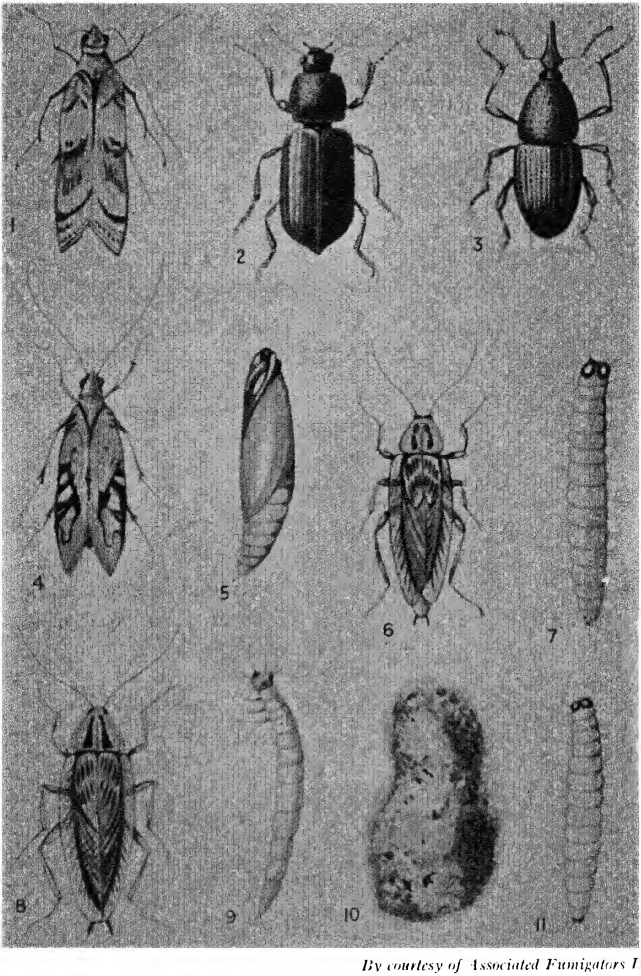
The larvæ of these latter insects are known as *meal worms.*

The eight types of insects mentioned above are the most important beetle pests of grain, but one other deserves mention :—

(*i*) *Sitodrepa panicea.*

This insect is known in America as "the drug-store beetle."

(*a*) *Sitophilus granaria.* The insect feeds upon the whole wheat berry. The mass of grain quickly heats up, with the consequent production of mouldiness. The eggs of the insect are laid in a peculiar way. An aperture is bored in a grain of the cereal attacked, the eggs being laid at the base of the opening. Subsequent to egg-laying, the insect fills the aperture with chitinous matter. The egg is thus sealed in by a reasonably impermeable layer, which renders its destruction



By courtesy of Associated Fumigators Ltd.

FIG. 23.

1. Flour moth (*Ephestia kuehniella*). 2. Meal beetle (*Tenebrio molitor*). 3. Grain weevil (*Calandra granaria*). 4. Corn moth (*Tinea granella*). 5. Flour moth pupa. 6. Cockroach (*Phyllodromia germanica*) (male). 7. Flour moth larva. 8. Cockroach (*Phyllodromia germanica*) (female). 9. Meal beetle larva (meal worm). 10. Flour moth chrysalis. 11. Corn moth larva.

difficult. *Sitophilus granaria* feeds on any kind of grain and has a strong natural instinct to remove itself as far as possible from any source of light. This weevil is not an outdoor insect and possesses no wings.

Sitophilus granaria may be controlled by the following methods :—

(i) *Aeration of the grain with cool dry air.* This renders the grain distasteful to the insect since it requires warmth and moisture which is removed by such aeration. The insect will not develop or reproduce below a temperature of 12° C.

(ii) If the grain is *stirred*, the weevils will leave. This is, however, merely a palliative measure.

It is obvious that low temperatures are not always practicable, while a temperature of 50° to 60° C. which will kill the insects may also damage the grain. In Germany copper oxide or copper carbonate dust has been mixed with such grain as was not intended for human food. This is said to act by drying out the weevils. This dust, however, becomes inactive in damp situations. Other methods of control are fumigation and spraying of the grain.

(*b*) *Sitophilus oryzæ*. This insect differs from *Sitophilus granaria* inasmuch as it possesses wings which are often used for flying. Its habits are, however, similar, except that it is often found out of doors, although this is not generally the case in this country. The methods of control are similar to those indicated in the case of *Sitophilus granaria*.

(*c*) *Caulophilus latinasus*. While this insect often feeds on grain, its food is more frequently spices, such as ginger, nutmegs, mace and turmeric. No investigations have yet been published on any special methods of

control. The usual methods of fumigation and spraying are used. Very little is known regarding its habits.

(*d*) *Trogoderma granaria.* This insect is much more important abroad, but may be carried to this country in imported foodstuffs. It will attack all kinds of grain, its usual habitat in this country being granaries and breweries. No special methods of control exist, fumigation and spraying being usually employed.

(*e*) *Tribolium castaneum* and (*f*) *Tribolium confusum.* These insects feed on a wide range of foodstuffs such as flour, cacao beans, dried fruits, peas, beans and other seeds. The usual habitat is flour mills and warehouses where such foods are stored. Growth is fairly rapid, the life cycle being correspondingly short. At a temperature of 27° C. this life cycle is completed in thirty-six days. The insects are not very resistant to the usual fumigants and sprays.

(*g*) *Tenebrio molitor* and (*h*) *Tenebrio obscurus.* These insects are known as meal worms and are largely confined to ground cereals such as bran and flour. They never attack whole grain. The life cycle is lengthy, being one to two years at the usual temperatures. These insects are the largest of the grain beetles and are attracted by damp situations which favour development and reproduction. There are no special methods of control beyond the usual fumigants and sprays.

(*i*) *Sitodrepa panicea.* This beetle is widely distributed and will attack almost any foodstuff. It is often found in domestic pantries. As it generally occurs in small infestations, heat is sometimes used to effect destruction, a temperature of 60° to 70° C. for forty-five hours being sufficient to kill all stages. The usual fumigants may also be used.

(2) **Moths.** These may be divided into two classes, those which attack whole grain and those which attack flour and crushed grain. The moths which attack whole grain are :—

(*a*) *Sitotroga cerealella.* Also known as the Angoumis grain moth. Not very important in this country.
(*b*) *Tinea granella.* Also known as the wolf moth. Allied to the common clothes moth.
(*c*) *Plodia interpunctella.* Also known as the Indian meal moth. The most important member of the group.
(*d*) *Corcyra cephalomica.* Of little importance in this country.

(*a*) *Sitotroga cerealella.* This insect attacks grain when in the field and is extremely prevalent in America. The grain attacked develops a characteristic smell, *débris* being also noticeable. Bread made from such grain is said to have caused diarrhœa and other gastric troubles.

(*b*) *Tinea granella.* This organism attacks wine corks and cigars. Its exclusion and destruction in corks is most important, since the apertures which it bores prevent efficient sealing of bottles. No special methods of control have been devised.

(*c*) *Plodia interpunctella.* This is an important moth which attacks grain, dried fruits, nuts and maize, being a major pest on the latter three foodstuffs. The genus *plodia* is found in conjunction with the genus *ephestia.* Both possess a life cycle which is important from the point of view of control. The eggs are laid on the foodstuffs attacked, upon which the larvæ feed. The fully grown caterpillars migrate from the foodstuff to hiding places in the storage premises towards the latter part of the summer, remaining *in situ* during the winter

which follows. They then emerge from hiding during the following summer as moths, infecting any grain or foodstuffs stored nearby. The removal of the foodstuffs is of little use in control because of this migratory habit. It is essential that the premises should be disinfected. This is no easy matter as the places used for hibernation are usually deep crevices. The common methods of fumigation and spraying are used in controlling this pest. In addition, as the caterpillar possesses migratory habits, it is usual to place a band of sticky material round the walls of the warehouse to which the migrating caterpillars adhere.

(*d*) *Corcyra cephalomica.* This insect is of little importance in this country. It chiefly attacks rice grain.

Only one important moth attacks flour and other crushed grain. This is the *Ephestia kuhniella* or Mediterranean flour moth. Another moth known as *Ephestia elutella* attacks a variety of foodstuffs.

(*a*) *Ephestia kuhniella.* This is an important moth. It is usually found in flour mills, where it attacks the flour. The caterpillars possess migratory habits. The mischief brought about by this moth is considerable, as conditions in flour mills are ideal for development. During its larval stage, the moth spins a variety of silk or webbing which traps flour dust and obstructs the flow of stock. Machinery becomes clogged, while repeated stoppages or breakdowns occur, with considerable loss in time and money.

(*b*) *Ephestia elutella.* This insect is also known as the cacao moth. It attacks cacao, dried fruits, tobacco, nuts and made-up cereals such as biscuits. It exhibits the migratory habits previously mentioned, and while fairly

resistant to control methods, is not so resistant as *Plodia interpunctella*.

Types of Fumigants. Many substances may be used for the disinfestation of foodstuffs and food premises. The following are the commonest articles employed for this purpose :—

(1) Hydrogen cyanide.
(2) Ethylene oxide.
(3) Ethyl formate (aeronal).
(4) Methyl formate (areginal).
(5) Carbon disulphide. This is often used in conjunction with carbon tetrachloride.
(6) Chlorinated hydrocarbons. These are not of any great importance in the control of insect pests in foodstuffs.
(7) Chlorpicrin. Used extensively in France for the disinfestation of foodstuffs, but its use in this country is not recommended by the Ministry of Health.

No hard and fast rule as to dosage can be given, since this varies according to the circumstances. When warehouses are being treated, successful fumigation depends upon whether or not the premises can be made gas-tight. The normal minimal dosages for the commoner types of fumigants may be stated as :—

(1) Hydrogen cyanide. 10 oz. per 1,000 cubic feet for 24 hours.
(2) Ethylene oxide. 10 to 12 oz. per 1,000 cubic feet for 24 hours.
(3) Ethyl formate. 1¼ lb. per 1,000 cubic feet for 24 hours.
(4) Methyl formate. 1½ lb. per 1,000 cubic feet for 24 hours.
(5) Chlorpicrin. 1 lb. per 1,000 cubic feet for 24 hours.

These dosages apply chiefly to grain weevils, but are reasonably general in application.

Mention should be made of a device recently patented for dealing with grain pests. In this method, the grain is passed along a conveyor, being subjected to an electric field between two poles during its passage. Weevils and other insects are killed by electric shock.

Fumigation. The success or failure of the fumigation of food supplies depends upon whether the fumigant employed can penetrate the material to be treated. In turn, penetration depends upon the inter-granular space existing between the grains of material in question. With the exception of dates packed in blocks and other dense foodstuffs, the inter-granular space is usually sufficient to allow such penetration. Various methods of packing, however, interfere with penetration.

When gaseous fumigation is resorted to, artificial assistance is often required to disperse the fumigant, particularly during cold weather. One of the commonest methods used for obtaining efficient vaporisation and diffusion is the employment of immersion heaters which warm the temperature of the water passing along one side of two corrugated surfaces. The fumigant is allowed to run over the opposite corrugation, the heat conducted from the water quickly assisting in evaporation and diffusion.

Foodstuffs may be fumigated in three different situations :—

(1) In warehouses or houses.
(2) In specially constructed chambers.
(3) In the holds of ships or barges. The tarpaulins used to cover the holds are practically gas-tight and, if properly battened down, will effectively seal the hold.

During the fumigation process it is essential that samples of the air and gas mixture in the space treated

should be taken at various levels. The routine practice of taking samples is a useful safeguard against failure brought about by leakages and other mishaps.

The principal gas used for the destruction of insect pests is *ethylene oxide*, the properties of which have already been described on p. 130. In ships and barges carrying foodstuffs, the holds should be sealed. Ethylene oxide itself or a mixture of ethylene oxide and carbon dioxide, known as ETOX, can then be pumped in with satisfactory results. The usual dosage has been mentioned on p. 132, but in the case of denser foodstuffs larger quantities are often used. The use of this gas has considerably simplified the work of disinfesting foodstuffs.

Objection may be taken to the use of a toxic gas for the fumigation of food supplies. It can be stated definitely, however, that foodstuffs are not affected by the gas in the slightest degree. Considerable research work has been carried out as to the effect of ethylene oxide on food. Sudendorf and Kroeger studied the effect of this gas on eighty-six different varieties of foodstuffs which were subjected to the gas in concentrations very much greater than those usually employed. Their conclusions may be enumerated as follows :—

(1) No trace was found of any exterior alteration in any of the foodstuffs treated.

(2) Fruit and vegetables showed no alteration in colour, while no withering, softening or collapse of the surface was observed.

(3) After six days the fresh fruit and vegetables showed no more signs of alteration than did the control sample.

(4) After a ventilation period of twenty-four hours, no taste or smell of the gas in any of the foodstuffs was noticeable.

Ethylene oxide possesses the following advantages in dealing with infested foodstuffs :—

(1) High toxicity at low concentration.
(2) Absence of fire danger.
(3) Low boiling point, rendering the gas effective and highly penetrative even at low temperatures.
(4) Little danger to operators even if inhaled for a reasonably lengthy period.
(5) No harmful effect upon the foodstuffs fumigated.

HYDROGEN CYANIDE. This is an ideal gas for fumigation purposes in many ways, but while some investigators state that it will not affect foodstuffs, others are of the opinion that the reverse is the case. It is much more difficult to use than ethylene oxide.

A satisfactory method of using hydrogen cyanide consists of fumigation by means of Zyklon, which has already received mention on p. 121. This is an effective method, while it is also clean and simple to operate. An outstanding advantage is that the hydrocyanic gas is prepared in the form of granules which are easy to handle. These are contained in canisters which are opened outside the building, the tops being sealed by means of rubber caps. The canisters are then placed in the required positions. When all is ready, the operators, equipped with gas masks, remove the rubber caps and sprinkle the material on old sacks laid upon the floor. The time of exposure is from eighteen to twenty hours, after which the premises are ventilated for a further five to six hours. Work of this description is usually carried out during week-ends and at holiday periods.

(2) ETHYLENE OXIDE. This gas is generally used in the form of ETOX (ethylene oxide and carbon dioxide). The technique is similar to that already

described for hydrogen cyanide. The gas is brought in cylinders, the requisite number of cylinders being placed in each room or on each floor. Special nozzles are fitted to the cylinder caps, the gas being released in the form of a fine white spray. The period of exposure is twenty-four hours, after which the premises are ventilated. The great advantage of this gas is that it will diffuse at reasonably low temperatures.

Contact Insecticides. As already indicated previously, gas can be used with advantage for fumigation purposes, provided a warehouse can be rendered gas-tight by thorough sealing. If foodstuffs can be removed to an airtight chamber they may also be treated successfully in a similar manner. Two problems, however, remain. In the first place, if the produce is moved out of the building, infestation may still be present to a greater or less degree. Secondly, fumigation cannot always be considered successful in warehouses because of the difficulty occasionally experienced in rendering the buildings gastight.

Because of this difficulty, it is sometimes necessary to spray food storage premises with *contact insecticides.* For this purpose a 5 per cent. solution of Lethane 38 in stainless kerosene may be used. A medicinal or white oil (Shell 2421) containing 0·8 per cent. pyrethrins may also be employed. The contact insecticides are atomised in a sprayer, a film being formed on the walls, internal fittings and exposed surfaces. This film is often obtained in large warehouses by forming a mist which settles on all internal surfaces.

A suitable spray is the paraffin gun similar to the type used for cleaning cars. When a large space has to be filled with atomised particles of the fluid, a number of

nozzles, generally six, are arranged in a circle, in order to spray simultaneously in every direction. With paraffin guns the piston type of air compressor is required. To obtain efficient atomisation a pressure of 60 lb. per square inch is essential. A film strength of 0·028 c.c. per square inch will kill *Plodia interpunctella* which is the most resistant of moths. This film is usually applied in May when the moths begin to emerge, and is repeated at weekly intervals.

CHAPTER XIV

DISINFESTATION OF SHIPS

Introductory. The infestation of ships is probably one of the most difficult problems with which authorities and owners have to deal. The eradication of pests and the prevention of re-infestation must of necessity vary somewhat from corresponding methods used on shore; while the fact that ships are constantly on the move renders the adoption of adequate control measures most difficult.

While cockroaches, ants and fleas are often found in large numbers on shipboard, bed-bugs and cockroaches are the most prevalent insects. In the case of ships making voyages through tropical waters, the period of development of the bed-bug is considerably shortened, so that the vessels very quickly become heavily infested. Such heavy infestations of forecastles or cabins may be detected on entering by the characteristic smell, a musty sour odour which cannot be mistaken. In addition, deposits of excreta will be seen on the bulkheads in the vicinity of the bunk brackets or sockets, and on the edges of the tongued and grooved woodwork.

Infestation Sites and General Measures. The crew's quarters are usually the site of the most severe infestations. There is now a tendency upon the part of the ship owners to house the crew amidships, near the

engine-room casing. Quarters in this position quickly become very warm, particularly in the tropics, and infestation rapidly spreads. The ordinary ship's forecastle contains :—

(1) Bunks in two tiers, sometimes constructed of wood but more often of hollow galvanised steel uprights fitted with brackets to support the bed irons or spring mattress. Side and end pieces are also provided. The top rails of the end pieces are hollow. The bunks may be provided with either straw mattresses supplied by the shipowner or with hair or Kapok mattresses supplied by the men.

(2) Wooden forms and tables.

(3) Wooden or steel clothing and food lockers.

Curtains are sometimes hung round the bunks, such curtains being supplied by the men. On many ships, four-berth cabins are provided for the crew. This procedure often has the effect of localising the infestation and facilitating eradication.

The principal sites of infestation found in the sleeping quarters exist in and around the sockets or brackets of the uprights, in the recesses of the side and end pieces, in hollow uprights and rails, in the corners and edges of the angle irons or steel mattresses, in the mattress springs, in the seams and leather buttons of stuffed mattresses, and in the grooves between the planking of the bulkheads. In addition to the above sites, the following may also be infested :—

(1) On the undersides of wooden forms and tables.

(2) Behind wooden lockers, particularly if situated near bunks.

(3) In cork lifebelts kept in sleeping quarters.
(4) In and around sea chests.
(5) On clothing, suits, etc., stored or hung near bunks, and in the folds of curtains, if present.

As might be expected, infestation is most marked in the vicinity of the bed.

The sources of such infestation vary, while investigations present considerable difficulty as crews move from ship to ship, carrying the vermin with them. It would be of the greatest assistance if all ports would notify verminous vessels to arrival ports. This information would enable all such vessels to receive immediate attention. Infested clothing and kitbags are often a source of infestation. In many instances such articles have become infested in verminous ships, lodging houses, and in the sailors' own homes. Bugs may be conveyed in the men's mattresses when moved from ship to ship, while second-hand books and laundry may also assist in dissemination. In addition to these sources the bugs may travel from one part of the ship to another.

In order to deal successfully with the problem there should be close co-operation between the various Port Health Authorities throughout the world, and also between such authorities and the Public Health Departments on shore. The regular use of soap and water and strict cleanliness should be inculcated upon the crew. The crew's quarters should be inspected at least once each week by the master of the ship. Woodwork should be painted with good quality oil paint. The use of water paints is unsatisfactory, as this cracks and flakes, providing an excellent habitat for the bugs. Tongued and grooved boards used for the lining of bulkheads

provide a suitable harbourage for the insects, particularly if any shrinkage occurs. In modern vessels, this type of lining has been abolished, being superseded by five-ply wood which is much more suitable as a vermin preventor. All bedding should be steam disinfected on the arrival of the ship in port. For this purpose, steam disinfectors should be provided at all dock areas to treat clothing and bedding. Many companies which provide bedding for the men arrange for this to be carried out.

Disinfestation Methods. Extermination methods depend upon the seriousness of the infestation and vary according to circumstances. In this connection it should be noted that in cases of heavy infestation the woodwork of the cabins should be stripped and burned. The various methods of disinfestation usually employed may be enumerated as follows :—

(1) Hydrogen Cyanide.
(2) Sulphur Dioxide.
(3) Contact Insecticides.
(4) Blow-lamps.
(5) Steam.

(1) HYDROGEN CYANIDE. Fumigation of ships by means of hydrogen cyanide undoubtedly represents the most satisfactory method of exterminating bugs and other insects together with their eggs, and should be used wherever possible. Its employment is, however, rendered difficult because of the occupation of the crew's quarters which may even present a problem when the ship is in port. In addition, men are usually at work unloading the cargo. Fumigation with hydrogen cyanide stops all work on the ship, and while it is in

progress all the crew must be removed. Shipping companies will not always agree to the delay which this procedure entails. Under the International Sanitary Regulations ships must be fumigated in order to destroy rats. Hydrogen cyanide is usually employed, but the specified dosages of 0·1–0·2 volume per cent., while destructive to rats, are insufficient to destroy bed-bugs and other vermin. If a ship is fumigated with hydrogen cyanide the dosage should never be less than 0·4–0·6 volumes per cent., applied for at least six hours. A concentration of 7–8 ounces per 1,000 cubic feet would be satisfactory.

The technique of ship fumigation by hydrogen cyanide may be divided into four stages, as follows :—

(*a*) Examination of the ship.
(*b*) Preparation of the ship.
(*c*) Process of fumigation.
(*d*) Ventilation.

(*a*) *Examination of the Ship.* Complete examination of the ship to be fumigated is necessary before any steps can be taken. The ship is divided into separate sections, which should be treated as separate units for gassing purposes. The position of the watertight doors and companions from one deck to another should be noted, and in passenger vessels note should be taken of all emergency exits. The ventilation system should be studied, so that one section of the ship may be isolated from another where necessary. Drainage pipes should be noted, since these require to be sealed from the interior. The position of pipes leading from one section to another should be checked. A survey of holds and cargo spaces should be made, the insulated areas noticed, and, if possible, the heavy hatch covers replaced with a

lighter, more portable type. The next step is to decide how the ship may be divided into suitable sections. The operators should make themselves familiar with the various watertight doors, ventilators, and any forced draught arrangements. In treating passenger accommodation, the distribution of the cargo spaces should be considered. When hatchways open into passenger areas, the lower holds must be battened down and treated as separate units. Finally, the various sections should be carefully measured for volume, and the quantity of gas required calculated. In estimating the amount of cubic space, use may be made of the capacity plan of the vessel which is usually carried in the chartroom. The figures giving what is known as the "grain skin capacity" are used.

(*b*) *Preparation of the Ship.* The ship is usually prepared for fumigation on the day prior to the treatment being carried out. Bedding should first be removed for steam disinfection. Water bottles and cabin and other water tanks should be emptied. Portholes should be screwed up, windows of public rooms accessible from the decks should be closed, left unfastened, but sealed with large sheets of paper from the exterior. All ventilators not in use should be closed by means of tight-fitting canvas covers, while attention must be paid to the various air-extractor ventilators and to the suction or forced draught fans. In addition, if the stokehold and engine room are to be treated, the funnels must be covered to eliminate any chimney draught. Sealing of the funnels is more important in the case of oil-burning ships which are not provided with chimney dampers. The bilges should always be pumped out before the holds are fumigated.

(*c*) *Process of Fumigation.* On the day during which the work is to be carried out, the sealing is completed. One member of the fumigation crew is made responsible for all keys, and it should be his duty to make quite certain that there is a key for every door on board, and that there are no locked doors. Hydrogen cyanide should never be discharged into a ship in which any door is locked. If the key of such door cannot be found, the door should be forced. Fire hoses should be laid out on deck and should be connected to a standpipe on the dock side. The boilers are shut down and the ship evacuated except for the fumigation crew. The ship should be carefully searched for stragglers and stowaways and a watchman placed at the foot of the gangway to prevent anyone coming on board. The exterior of the hull should be examined to ensure that no portholes are left open and that no ropes and ladders are hanging over the side. A notice board displaying a notice forbidding craft to moor alongside is placed on the offside of the ship. This notice should state that the vessel is under poison gas, while a similar warning should be placed at the foot of the gangway.

The fumigation squad should search the ship, hooking back the doors of cabins, opening wardrobes, drawers and lockers, and ensuring that all water, foodstuffs, etc., have been removed. Each hold should also be searched. The necessary watertight doors isolating the previously arranged sections are closed, with the exception of one door in each section. These doors should be sealed with paper and paste. Gas masks should then be examined and adjusted, and first-aid materials laid out in a convenient position.

The fumigant is divided into two portions, one being

placed forward and one on the after deck. The materials are then allocated to each section in which canvas sheets, painted on both sides, have been laid out. Each section is searched again, and is then ready for gas.

Probably the simplest method of fumigation with hydrogen cyanide is the use of Zyklon, a substance which has already received detailed mention on pp. 121–122. Sufficient tins of Zyklon are opened on deck, rubber caps being fitted to replace the lids and to prevent loss of gas. These tins are placed in compartments and alleyways, in suitable numbers for each section to be treated. The squad is divided into companies of two, one pair taking the starboard side of the ship, and the other, the port side. At a given signal, the operators scatter the contents of the tins evenly on the canvas sheets, leaving the accommodation by means of the prearranged exit. The work is begun at the point furthest from the exit, the squad working towards the outlet of each section. In this way the men are not exposed to heavy concentrations of gas.

When dealing with holds, the tarpaulin cover should be removed at one corner and the Zyklon emptied down the hold, the hatch boards of the lower holds having been previously removed, the tarpaulin being thereafter replaced. This operation occupies a few minutes at most.

Liquid cyanide may be used by employing the *Galardi method of distribution*. The procedure is almost exactly similar to that of the Zyklon treatment, except that the bottles are opened *inside* the section to be treated and immediately inverted into rings or tripods standing on small trays upon the canvas sheets previously mentioned.

When the distribution of gas has been completed, the outlet from the treated section should be properly sealed with paper and paste. The next section is then taken in hand, the work progressing in this manner until the whole of the vessel is under gas. When the last section has been sealed, all outside ventilators, door, windows, etc., should be examined to ensure that no leakages exist. It is particularly essential to retain a high concentration of gas in the different compartments which necessitates efficient sealing. It should be noted that large ventilator areas always permit a certain amount of leakage on the lee side of the ship, however well the canvas covers fit.

(*d*) *Ventilation.* At the appointed time for opening up, the operators should fix and test their masks and proceed with the ventilation of the ship. The upper deck is dealt with first, funnel covers being removed, engine room ventilators uncovered, skylights opened, and fan suctions unsealed. The ventilators should be properly trimmed to facilitate removal of the gas. Officers' quarters and chartroom should be opened out, after which the squad descends to the next deck. Here the paper should be removed from the windows and, commencing at the lee side, all windows are opened, followed by those on the windward side. Hatches are unbattened and portable bulkheads broken down; indeed, every fixture which it is possible to reach from the decks should be opened. Ventilation is allowed to proceed for two hours before any further steps are taken.

When this period has elapsed the men working in pairs open the portholes on the lee side, followed by those on the windward side. Each deck is dealt with in

this manner until all the portholes have been opened. The lower holds opening into passenger accommodation are next opened, windsails being erected for every batch. The engine room and stokehold are carefully tested, and when these are safe to enter the engineers should start up the electrical generators. All doors leading from the engine rooms into the ship's accommodation should, however, be kept locked and a warning notice posted on each door.

When sufficient steam pressure is available the electrical generators should be started and the forced draught system put into operation. While air is circulating through the ship all residues should be removed. After forced draught and natural ventilation systems have been working for some hours, tests of the atmosphere in various parts of the ship should be carried out. The tests normally used have already been described on pp. 162–163. Testing operations begin on the upper deck, the work proceeding systematically deck by deck, cabins, public rooms, wardrobes, drawers, lockers and upholstery being carefully tested. Sections difficult to ventilate are usually aired by means of portable electric fans. Dunnage in the holds should be turned over and aired, while tanks, with covers removed, should always be carefully tested. In addition, 'tween decks, mail and baggage rooms and bunkers should receive attention. Bedding and pillows should be beaten in the open air.

When the supervisor is satisfied that the ship is safe a final inspection should be made without gas masks, tests being carried on throughout the ship. When all is clear, the fumigation flag is hauled down, danger notices are removed, and the ship is turned over to the officer of the watch. Warning should always be given that no

rooms which have been fumigated should be slept in before twenty-four hours have elapsed following the all clear being given.

(2) SULPHUR DIOXIDE. Fumigation with this gas is of very little use. It may prove effective provided sufficient concentration and exposure are given and provided a humid atmosphere is maintained, but it cannot be trusted to kill the eggs. In addition, ventilation is difficult, because of the slow movement of the gas.

(3) CONTACT INSECTICIDES. Although fumigation by means of hydrogen cyanide is the obvious method of choice, contact insecticides may be applied by means of a very fine spray, and will give reasonably satisfactory results provided the work is adequately carried out. In addition, such insecticides may be taken to sea and used periodically by the crew to keep down insect pests while the ship is in passage.

(4) BLOW-LAMP. The blow-lamp may be used with considerable effect. Systematic use is required.

(5) STEAM. This is rarely used because of difficulties experienced in carrying the steam to the various parts of the vessel. In addition, even when this difficulty is overcome, steam cannot always be used in every part of the vessel. Instances are recorded where the use of steam has resulted in 100 per cent. destruction of insect pests.

Cockroaches and Beetles. Cockroaches and beetles on shipboard may readily be destroyed by means of a good quality *insecticidal powder*. This should be applied by means of a duster, and repeated applications will be necessary as this treatment does not destroy the eggs. These must be allowed to hatch out, and the young destroyed by the succeeding applications. Messrooms

and galleys are often seriously infested with such insects, in addition to which *firebrats* and *silverfish* are often in evidence.

Advantages of Disinfestation. The advantages to be obtained from the disinfestation of vessels are :—

(*a*) Freedom from insect pests.
(*b*) Freedom from complaints by passengers.
(*c*) Freedom from claims for damage done to goods in transit.
(*d*) Freedom from irksome foreign inspections, particularly if hydrogen cyanide has been used.
(*e*) Freedom from discontent among the crew due to the presence of vermin.

APPENDIX I

FORMS AND RECORDS

Form of Request for Treatment

HACKNEY BOROUGH COUNCIL

Public Health Department

REQUEST FOR DISINFESTATION OF ROOMS, FURNITURE, CLOTHING OR OTHER ARTICLES

I, ...,

of . . . .

request the disinfestation at my own risk of . . .

. . . . at

Premises . . . .

Articles . ...

. .. .

Disinfestation to be done with ....

Date to be done . . Done by. ... . Date . . . .

Payment to be made ....

Cash or account to be sent . ...

Remarks . ...

. . . .

Form of Request for Treatment

HACKNEY BOROUGH COUNCIL

Public Health Department

REMOVAL AND DESTRUCTION OF UNWHOLESOME OR VERMINOUS MATERIAL

I, . . .

of .

being the owner of .

. . .

now at the premises .

request the removal of, and agree to the destruction of the above articles, materials, etc., by the Public Health Department.

. . .

DISINFECTOR'S REPORT

Articles or nature of material . . ..

.. ..

. . . .

Reason for removal and destruction . ...

.. . .

Done by.... .. .. Date . . . .

Form of Report on Fumigation

METROPOLITAN BOROUGH OF HACKNEY

Public Health Department

FUMIGATION OF FURNITURE, ETC., WITH HYDROGEN CYANIDE AT DISINFECTING STATION, MILLFIELDS ROAD, CLAPTON, E.5.

Request for fumigation by . .. . . .
Date required . .
Address from which goods to be removed . . . .
Address to which goods to be removed .
Time at which van may be expected to arrive at Fumigation Station . . . . .
Number of families' furniture in van, if more than one .
Is bedding to be collected separately or to be brought in by furniture van ? .
Is any furniture to be collected for destruction ? .
Is warning letter to tenants being sent by applicant ? . .
Account to be charged to . ... ..

Signed . ...

Please return form as soon as possible before date on which fumigation is required to

THE MEDICAL OFFICER OF HEALTH, TOWN HALL, MARE STREET, HACKNEY, E.8.

Form of Notice to Occupier

THE METROPOLITAN BOROUGH OF HACKNEY

To . ...of ....

The removal of your furniture, etc., to . . . . .

. . . . has been arranged for. . 194 .

Before delivery to the new premises the furniture and effects will be fumigated with HCN and the bedding will be disinfected. Furniture, etc., should not be packed tightly.

Articles of *food, drink, drugs and dressings, plants, wet articles or wet clothes must not be put in with the furniture, and kettles and vessels containing liquid must be emptied before removal.*

Gas masks must not be packed with furniture, but should be conveyed by yourself to the new home.

Money, valuable papers or jewellery must not be put in the van, but should be conveyed by yourself to the new premises.

Furniture and bedding will be returned to the new address as early as possible the same day.

Where needed, please clean articles before day of removal.

Old bedding and furniture, etc., which you do not wish to take with you will be collected by the Council's vans for destruction at your request, free of charge.

It will be an advantage if you are ordering any *new* furniture or bedding, etc., to arrange to have this

delivered by the dealer direct to your new address on the day of removal.

Please keep the windows of your new premises open, and the rooms well ventilated, on the first evening and night of occupation.

The removal of the furniture will commence as early as possible, about... .. ..

Bedding, bolsters, pillows, eiderdowns, cushions, blankets and other bedding material will be collected separately by the Hackney Borough Council's vans as early as possible, about . . and must not be put in with the furniture in the furniture van, unless you are requested to do so.

G. H. DART,
Medical Officer of Health.

Form of Daily Return of Disinfections

METROPOLITAN BOROUGH OF HACKNEY

Public Health Department,
Town Hall, Hackney, E.8.

Issued to .... Date . . . .

DAILY DISINFESTING AND DISINFECTING LIST

Name	Address from which to be removed	Address to which to be removed	Remarks

Forms of Register

METROPOLITAN BOROUGH OF HACKNEY

Register

HCN CHAMBER FUMIGATIONS—REMOVALS

Serial No.	Date	From	To	Name	Steam Disinfection		HCN used	Amount paid	Done for	Remarks
					Beds	Other Articles				

METROPOLITAN BOROUGH OF HACKNEY

Register

HCN FUMIGATIONS (NOT REMOVALS)

Serial No.	Date	Articles	Reason for Fumigation	Owner	Address	Amount Paid	HCN used	Remarks

THE ROYAL BOROUGH OF KENSINGTON

Date... ....19. .. .

DISINFESTATION REQUISITION

From whom received	Name of Family	Address		Date proposed for execution	Date completed	Particulars of any damage. (If no damage state NO DAMAGE DONE)	Remarks. (Action taken regarding damage, etc.)
		From	To				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

.... Officer responsible for Columns 1—5

.... Officer responsible for Columns 6—9

NOTE.—This copy to be forwarded to B E. Dept. after completion of Cols. 1–5, and returned to P.H. Dept. after completion of Cols. 6—8.

Form of Request for Treatment

No.

DISINFESTATION

I request the Council of the Royal Borough of Kensington to disinfest the premises known as , and in consideration of no charge being made for this service I agree that such disinfestation work will be carried out by the Council at my own risk. I undertake to be responsible for, and to indemnify the Council against, all actions, proceedings, claims and demands, and all costs, expenses, losses and damages, either present or future, caused by or arising out of the said disinfestation work or work incidental thereto.

(*Signed*) . .

(*Witnessed*)....... ....

Date ... .

Form of Notice to Police of Fumigation

No . .. .

Public Health Department,
Town Hall, Kensington, W.8.

. . . 194 ..

NOTICE OF FUMIGATION OF PREMISES WITH POISON GAS (HCN)

You are hereby notified that the staff of the Public Health Department will fumigate the premises known as ....
on day, ...194 . ..

The house will be under gas from . . .. a.m. till . . . p.m., when ventilation will be commenced. It will be dangerous to life to enter the premises during fumigation and between the time ventilation commences and.. .... a.m. / p.m.

....

Medical Officer of Health.

To ... .

. . . .Police Station,
Kensington, W.

Form of Notice to Occupier

THE ROYAL BOROUGH OF KENSINGTON

Public Health Department,
Town Hall, Kensington, W.8.

. . 194 .. ..

DEAR SIR OR MADAM,

In order to deal with the disinfestation of the block of houses Nos. on . . .. . ,
I have made the following arrangements :

1. The van will collect all your bedding on .... before 9 a.m.

2. No Seymour King Buildings will be ready for you by 9 a.m. on that day, or as soon after as you care to occupy it.

3. Your house will be treated by cyanide, and will be disinfested on.................. .. ..
....

4. It will be opened some time on.. .. . .
and you will not be able to take possession of it until after a certificate has been handed to you by the Officer-in-Charge of Disinfestation.

5. The bedding will be returned on ....

6. Everything will be provided for your use at No. Seymour King Buildings, and all that you need to take will be sufficient food for all meals to be taken there.

7. The food should be taken to this address on .. and handed to the caretaker. For this purpose I will send you a box in which the food is to be packed.

8. NO FOOD MUST BE LEFT IN YOUR HOUSE.

9. The caretaker of Seymour King Buildings will do all in his power to make you comfortable during your stay there, and I am sure you will do all in your power to carry out these arrangements without a hitch.

Yours faithfully,

Medical Officer of Health.

Form of Weekly Record—HCN

THE ROYAL BOROUGH OF KENSINGTON

DISINFESTATION WORK: (1) HCN PLANT

Week ended 194 ..

Date	Family	Moved from	Moved to	Time of		Condition of furniture	Wt. of bedding (lb.)	No. of articles of bedding	Wt. of furniture	Remarks
				Leaving	Arrival					

Form of Weekly Record—Spray

THE ROYAL BOROUGH OF KENSINGTON

DISINFESTATION—SPRAY WORK

Week ended .... 19 .

	R.B.K. property	Other property
No. of houses treated with—		
heavy naphtha	.	.. ..
Keritox	. . .	....
sulphur	.. . . .	....
No. of families using the clearing house	. .	....

Details of work

Date	Premises	No. of rooms	Substance used

Form of Weekly Summary

THE ROYAL BOROUGH OF KENSINGTON

DISINFESTATION—HCN

Week ended . ..194 ....

Summary of removals

No. of families moved .
Kensington
Holborn
Hammersmith
Paddington . .
St. Marylebone
Fulham .

No. of loads . .
Kensington ...
Holborn
Hammersmith . . .
Paddington
St. Marylebone . ...
Fulham . .....

Amount of bedding treated

	Kensington	Holborn	Hammersmith	Paddington	St. M.	Fulham	Total articles
Mattresses & bedding.							
Bolsters & pillows.							
Quilts.							
Blankets & sheets.							
Sundries.							

	Tons.	cwt.	qr.	lb.
Total weight of above bedding				
Kensington				
Holborn	.	....		
Paddington				
Hammersmith				
St. Marylebone				
Fulham				
Total weight of furniture removed	.			
Kensington	. .			
Holborn	.			
Hammersmith				
Paddington	..... .			. ..
St. Marylebone				...
Fulham	.			. .. .

APPENDIX II

SPECIMEN PROPAGANDA LEAFLETS

No. 1

BETHNAL GREEN BOROUGH COUNCIL

INSECT PESTS AND WHAT TO DO ABOUT THEM

Insect pests are a disagreeable subject which everyone wishes to avoid. But vermin are not only uncomfortable, they are dangerous because they may help in the spread of disease. Therefore the only thing to do about them is to **destroy them.** This is not a simple matter for the ordinary family, who may be living in a small one or two room tenement without proper means of bathing. Old houses, furniture and bedding also harbour vermin in a way that makes ordinary domestic cleansing insufficient to get rid of them. Bearing the difficulties in mind, the Borough Council offers practical help in three ways :—

(1) By enabling *adult persons who are affected to have a thorough cleansing bath.

(2) By disinfecting the clothing and bedding which are likely to be affected with vermin.

(3) By disinfecting furniture and rooms which are infested with vermin.

All these services are free of charge.

Any family may have the misfortune to become infested with one or other of the following pests :—

* The L.C.C. deals with school children at the Bathing Centre at 5a, Russia Lane.

Bugs are not only a nuisance to those who suffer from their bites, but they are dangerous as possible carriers of disease. It is therefore most important that they should be promptly and thoroughly destroyed. This is often difficult to do by purely domestic means, as the eggs of the vermin escape destruction by ordinary household cleansing or disinfection. Sprinkling carbolic about the place or painting spirits of salts on the wall may waste money and time and is not likely to get rid of bugs, which hide behind skirting boards and other woodwork. The only good way to rid bedding and clothing of bugs is by Steam Disinfection, and by the thorough chemical disinfection of the walls, etc., of the room, for which purpose it is frequently necessary for the landlord to loosen or remove the woodwork. Disinfestation of the furniture may also be required. These measures will undoubtedly destroy practically all the bugs and their eggs in a room, but it is possible that a few may reappear. There are some cases in which there is only a slight infestation of bugs and all these measures may not be necessary. It is well to remember, therefore, that the best protection against vermin of all kinds is scrupulous cleanliness by the energetic use of ordinary soap and water. As a further help, the Public Health Department will lend a sprayer and supply a quantity of a special solution which will suffice to kill bugs when they are few in number and happen to be easily accessible.

Fleas are not so bad a nuisance as bugs, but they ought also to be promptly destroyed as soon as noticed. They hide particularly in clothing and bedding which should be sent to the Disinfecting Station to make sure of the destruction of the pests.

Body lice are different from the lice found in the hair. Body lice live in the clothing and bedding, and bite the skin of the infected person from time to time in order to extract blood, which serves as nourishment to them. These bites cause irritation and annoyance. Body lice lay eggs or "nits" in the clothing and these hatch out into young lice. These "nits," like the "nits" of the head louse, are very difficult to destroy. Washing the clothing and the body in hot water does not destroy the nits, but ironing the seams of the clothing with a hot iron or scrubbing the seams with a *hard* tooth brush dipped in petrol are very useful methods.

Head Lice and Nits. Although children are the chief victims, adults are often affected. Wash the head with soft soap and hot water. Dry. Soak hair in ordinary paraffin oil, keeping away from fire or gas flame. Wrap head in cloth and leave overnight. Repeat washing with soft soap and hot water next day. This procedure kills the lice and nits. To remove nits which still remain in the hair, soak hair daily with warm vinegar and comb with small metal tooth comb till all nits are removed. (The nits are "glued" to the hair, and the hot vinegar dissolves this cement.)

Scabies (Itch). This is a very troublesome disease, caused by the itch mite, which lays its eggs under the skin. The individual notices that the itching is worse at night when warm in bed, and gives rise to a considerable amount of scratching, which may lead to infection of the skin and the production of sores. The mites may choose any part of the body and particularly prefer the parts between the fingers. Treatment consists (i) in taking a hot bath and scrubbing the whole body thoroughly with a stiff brush and soap ; (ii) immediately

fterwards, when dry, rubbing gently over the whole ody a thin layer of sulphur ointment ; (iii) putting on lean underclothing and clothing ; (iv) the disinfection f the left-off clothing either by the Council or at home ; 1 the latter case, woollens should be washed in warm vater with a suitable disinfectant, while other articles hould be boiled. These processes should be gone through n three alternate days at least. After the third treatnent the bed linen and bedding should be thoroughly isinfected. The most satisfactory way to carry out reatment is to apply at the Council's Personal Cleansing tation, where special ointment is provided and the reatment can be completed in three consecutive days. 'he clothing and bedding can be disinfected while the atient has his or her bath.

Don't be led away by false sentiment to refuse the pportunity of getting rid of these loathsome insects and f making a fresh start thoroughly clean. The Borough 'ouncil has power under the law to *enforce* cleanliness. But it is much more satisfactory to arrange things by onsent.

Therefore, when the Sanitary Inspector calls upon you o arrange about disinfection, you will be acting wisely 1 the interests of your family and the public health to ave the job done promptly and thoroughly.

* * *

Please note :

That the **Personal Cleansing Station** is situated at the Disinfecting Station, Digby Street, and is open as follows :—

MEN—Monday to Friday, 9 a.m. to 12 noon.
Saturday 9 a.m. to 11.30 a.m.

WOMEN—Monday to Friday, 2 p.m. to 4 p.m.

If for any reason you miss the Sanitary Inspector, write a note to the Medical Officer of Health, or call at the Public Health Department, Patriot Square, and arrangements will at once be made for room, individual, or clothing and bedding to be disinfected.

Remember

Sunlight, Fresh Air and Soap and Water are the best disinfectants.

Good Health and Cleanliness usually go together.

No. 2

BOROUGH OF BETHNAL GREEN

The Lament of a Female Bug

War! War on the bug! And to what end? Ours without doubt. I speak of the nerve-racking offensive being steadily and alarmingly developed against the bug race by bodies of individuals called Local Authorities. These, I may explain, are the people who, amongst other things, take care of the public health. Those of you who have never run the gauntlet of direct hits and poisonous gases cannot possibly appreciate the terrible catastrophe that threatens our very existence. Moreover, our aggressors are waging this increasingly intensive campaign of destruction without the recognised formality of an official declaration of war. It is unwarrantable!

Probably you have heard their reasons for what I choose to call their unprovoked assaults on our territory and homes. It is only fair, therefore, that you should hear our side of the question.

First of all, let me state my own case. Neither selfishness nor egotism impels me to bring myself into the limelight, for I much prefer tucking myself inconspicuously away in some dark niche. As a matter of fact, all our race have this modest retiring disposition. We abhor publicity in any shape or form.

Well now ! I am the proud mother of countless sons and daughters, grandchildren and great-grandchildren. I lay, on an average, some two or three eggs a day, and during my lifetime my expectation is between two and three hundred eggs. These hatch in about one to three weeks, and, after five or six moultings, the young bugs become full-grown. Under favourable conditions the whole process of development takes about six weeks. If " sanctions " are applied, however, and food is scarce, development will take about ten weeks. These facts should prove that we female bugs are not shirking our responsibilities. We never attend ante-natal clinics nor take our offsprings to welfare centres, for the simple reason that we are not so lucky as you. We have none of these services in Bugland. Of course, our infant mortality rate is high, but what else can be expected ? And still Local Authorities want to make it higher.

These days, I believe, you hear a lot about depression and malnutrition. We bugs seldom feed more than once a week, and sometimes we have to go without a meal for as long as six months. Are we in the depths of despond on account of that ? No ; we keep a stiff upper lip. You have probably heard the saying : " as happy as a bug in a rug." Of course, we freely admit that if we had welfare centres where we could obtain extra nourishment, we should be happier still.

But to return to the horrors of war. It has been

related from generation to generation in all our families that Local Authorities are our hereditary and most bitter enemies. Having collected into their armoury the most modern methods of chemical warfare, we must necessarily look to our lines of defence. Accordingly we entrench ourselves behind skirting boards, architraves, and pictures, in chests of drawers, upholstered furniture, bedsteads and crevices in wood and plaster. We must live- at least we think so—despite this state of siege and so, whenever the time appears opportune, we cautiously emerge from our strongholds during the night, making occasional sorties and scouting around in search of sustenance. We are a peace-loving race, and our actions are not based on malice and retaliation, but on sheer necessity. I may also say that we have the deepest—I might say most clinging—affection for the human race, and I am only voicing the sentiments of my own race when I tell you that it has always been and always will be our greatest ambition and desire to foster the most intimate relations with you.

In spite of these peace overtures, I fear we are faced with extermination, and I really do not see what more we can do about it. Those terribly implacable Local Authorities are now employing more lethal things like orthodichlorbenzine and hydrocyanic acid gas, a form of chemical warfare absolutely in defiance of the Hague Convention and the League of Nations. I don't think it is playing the game.

Another blow! We never used to worry when houses unfit for human habitation were demolished because those of us that could not stow away with the furniture in the removal van, and so get into a nice new flat, could easily migrate elsewhere. Alas! That has all been

changed! Under the new Housing Act, Local Authorities are given power to get rid of us (they use the nasty word "disinfest") from these old houses before demolition. And what is more disconcerting, they are now fumigating the loaded removal van with hydrocyanic acid gas before the furniture and other effects are taken into a new home.

How can they be so heartless! It is distinctly laid down in the Housing Acts that suitable alternative accommodation must be provided for those displaced. We are not getting our rights.

Just one more final confidence. I have heard that tenants are being asked to co-operate by doing their bit towards our extermination, and that soap and water, sunlight and fresh air are the best disinfectants in the world. And believe me, we bugs know it to our cost. I am sure you will see what a disastrous effect it would have on us if you betrayed that secret, and these suggestions were carried out. Woe is me and mine! We should be wiped clean out of existence.

"And a jolly good thing too," says

VYNNE BORLAND,
Medical Officer of Health.

Town Hall,
Bethnal Green, E.2.
June, 1936.

Important Postcript.—Residents who suffer from Bugs and want help in getting rid of them should apply to the Public Health Department at the Town Hall.

No. 3

HACKNEY BOROUGH COUNCIL

Public Health Department

VERMINOUS PREMISES

At the request of owners or occupiers, verminous premises will be fumigated by the staff of the Public Health Department at a charge of two shillings and sixpence each room. Payment must be made at the office at the Town Hall or on the premises before the work is commenced.

The rooms will be closed for about eight hours, but preferably all night. They will be closed and opened by the disinfectors, but occupiers should see that the rooms are free from fumes by thoroughly ventilating them and shaking or beating the bedding and clothing before again occupying the rooms.

Articles of silver or plate and delicately coloured silk or velvet garments, etc., should not be left in the rooms, and the Council cannot accept liability for alleged damage done to any of the contents of the rooms.

NOTE.—Fumigation usually kills bed bugs at the time of fumigation, but the ultimate extinction and the keeping of the premises free from vermin depends upon the efforts of occupiers.

The life of a bed bug varies from weeks up to four years or more. The eggs are laid in the crevices of bedsteads, on mattresses, behind wall-paper, skirting boards and mouldings, around doors and windows, picture frames, etc.

Under normal conditions a female bug will lay

two or three eggs a day, and during her life may lay 100 to 200 eggs.

The eggs ordinarily hatch in from one to three weeks, but sometimes the period is much longer.

The bug can exist without food for long periods.

Deposits of black excreta in the form of small dark spots indicate the places where bugs are hiding.

Bugs can be introduced by means of secondhand furniture and bedding or by firewood from old houses, and they will migrate from room to room and house to house.

Excellent results can be obtained by thorough and systematic cleaning and scrubbing with hot water, soap and soda with a little disinfectant added.

Fabrics and upholstery should be well brushed and beaten to dislodge bed bugs and their eggs. Useless and valueless articles should be burnt or destroyed.

The Public Health Department will assist occupiers by removing for destruction free of charge verminous or unwholesome bedding and articles of furniture.

A spraying liquid and hand sprays are supplied by the Public Health Department at a moderate price: this liquid, if properly applied, destroys the vermin and the eggs in cracks, in defective plaster, behind woodwork, and in places where it is difficult to scrub and clean.

Occupiers must destroy the eggs as well as the live bugs, and frequent thorough cleaning of the rooms and contents is necessary.

G. H. DART,
Medical Officer of Health.

October, 1934.

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PRINTED IN GREAT BRITAIN BY THE WHITEFRIARS PRESS LTD.
LONDON AND TONBRIDG